(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 318 509 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
11.06.2003 Bulletin 2003/24

(21) Application number: **01965596.8**

(22) Date of filing: **12.09.2001**

(51) Int Cl.[7]: **G11B 7/007**

(86) International application number:
PCT/JP01/07927

(87) International publication number:
WO 02/023542 (21.03.2002 Gazette 2002/12)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **13.09.2000 JP 2000277775**

(71) Applicant: **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**
Kadoma-shi, Osaka 571-8501 (JP)

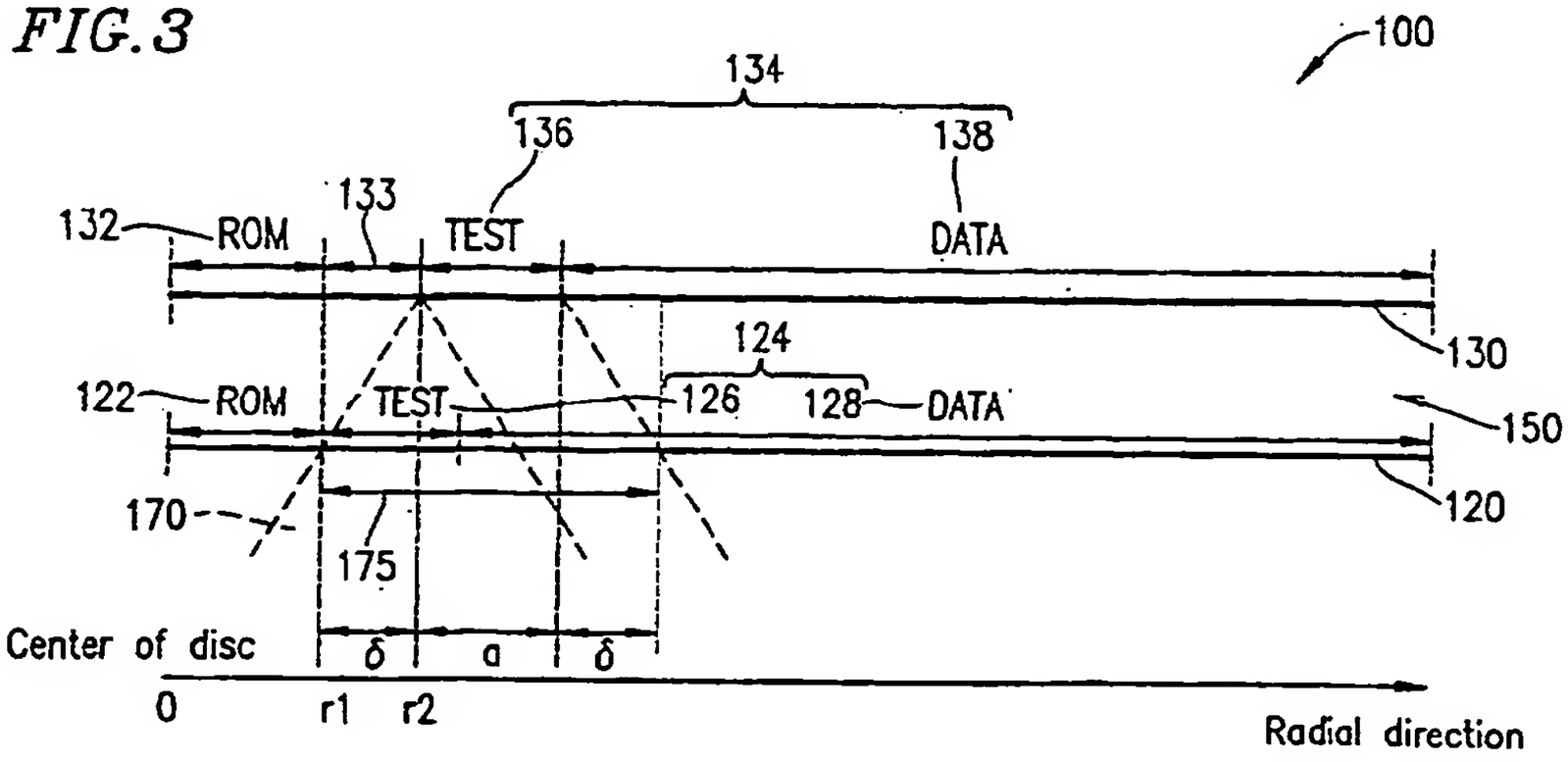
(72) Inventors:
- **NARUMI, Kenji**
  Ibaraki-shi Osaka 567-0882 (JP)
- **NISHIUCHI, Kenichi**
  Hirakata-shi, Osaka 573-1135 (JP)

(74) Representative: **Holmes, Miles et al**
Novagraaf International S.A.
25, avenue du Pailly
1220 Les Avanchets, Geneva (CH)

(54) OPTICAL INFORMATION RECORDING MEDIUM AND OPTICAL INFORMATION RECORDING METHOD, OPTICAL INFORMATION RECORDING DEVICE

(57) An optical information recording medium according to the present invention includes a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer. The first information recording layer includes at least one of a reproduction-only area and a recording and reproduction area. The second information recording layer includes a test recording area. At least one of the reproduction-only area and the recording and reproduction area, and the test recording area is located such that one of the reproduction-only area and the recording and reproduction area includes an area of the first information recording layer through which the laser light for recording information in the test recording area passes.

FIG. 3



EP 1 318 509 A1

Printed by Jouve, 75001 PARIS (FR)

INSDOCID: <EP_____1318509A1_I_>

Description

TECHNICAL FIELD

[0001] The present invention relates to an optical. information recording medium, an optical information recording method and an optical information recording apparatus, for optically recording information. In more detail, the present invention relates to an optical information recording medium including a first information recording layer on which information is to be recorded by laser light and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer; and a method and an apparatus for the optical information recording medium.

BACKGROUND ART

[0002] Recently, optical discs, optical cards, optical tapes and the like have been developed as optical information recording media for allowing information to be optically recorded. Among these, optical discs have attracted attention as optical information recording media for allowing a large capacity of information to be recorded at high density.

[0003] One type of rewritable discs are phase-change optical discs. A recording layer used for a phase-change optical disc is reversibly changed to either an amorphous state or a crystalline state, depending on the conditions of heating by laser light and the cooling conditions. The recording layer has different optical constants when in an amorphous state from when in a crystalline state. Therefore, in the case of a phase-change disc, one of the two states is selectively formed in the recording layer in accordance with information to be recorded, and the resultant optical change (i.e., a change in transmittance or reflectance) is utilized. Thus, information recording and/or reproduction can be performed. In order to obtain the two states, information is recorded as follows.

[0004] A recording layer of an optical disc is irradiated with pulse-type laser light (referred to as a "recording pulse") at a power for raising the temperature of the recording layer to equal to or higher than the melting point. As the laser light passes, the melted portion of the recording layer is rapidly cooled into a recording mark in an amorphous state. Alternatively, the recording layer is irradiated with focused laser light at a power for raising the temperature of the recording layer to a point equal to or higher than the crystallization point but equal to or lower than the melting point. Then, the portion of the recording layer irradiated with the laser light is placed into a crystalline state.

[0005] An optical disc is a recording medium which is exchangeably mounted with other optical discs on an optical disc recording and reproduction apparatus. Therefore, the optical disc recording and reproduction apparatus needs to stably perform recording on or reproduction from a plurality of optical discs. Even optical discs produced under the same conditions may have different recording mark states or may be differently influenced by thermal interference between recording marks, due to different thermal characteristics thereof which are caused by dispersions at the time of production and/or time-wise changes. This may result in different recording conditions including the recording power for the optical disc and the optimum edge position of the recording pulse.

[0006] In order to stably record information without being influenced by changes in such recording conditions, an optical disc recording and reproduction apparatus obtains recording conditions before recording information on an optical disc. Specifically, before recording information on an optical disc, an optical recording and reproduction apparatus performs test recording using a specific data pattern (referred to as "test information"), reproduces the test information, and measures the reproduced signal so as to obtain the recording condition. This process is referred to as "test recording". Optical discs have an area used by the test recording, which is referred to as an "test recording area".

[0007] A rewritable disc has a reproduction-only area pre-formed in a specific portion. The reproduction-only area includes convex and concave phase pits. In the reproduction-only area, information which does not need to be rewritten, for example, information on the optical disc itself or address information, is recorded. This area is also referred to as an "emboss area".

[0008] An area in which information is recorded by forming a recording mark is referred to as a "recording and reproduction area". In the recording and reproduction area, information which has a possibility of being rewritten is recorded.

[0009] A general rewritable optical disc has a data area in a central portion in a radial direction thereof, and has a lead-in area in a portion internal with respect to the data area, and a lead-out area in a portion external with respect to the data area. In general, an area for recording management information of the optical disc and/or a test recording area is provided in the lead-in area and the lead-out area.

[0010] Recently, there has been strong demand for the optical discs with a higher recording density. In response to this demand, a multi-layer recording medium having two or more information recording layers in a thickness direction of the disc is proposed. Information can be recorded on each of the information recording layers.

[0011] In such a multi-layer recording medium, each of the information recording layers often have different recording characteristics. This requires test recording to be performed for each information recording layer. One exemplary method of such test recording is disclosed in Japanese Laid-Open Publication No. 11-3550.

[0012] However, conventional methods do not con-

EPNSDOCID: <EP 1318509A1 | >

sider the following phenomenon. When test recording is performed on an information recording layer of a multilayer recording medium which is far from the laser incidence surface (the information recording layer far from the laser incidence surface will be referred to as a "second information recording layer"), the second information recording layer is influenced by the state of an information recording layer which is closer to the laser incidence surface (the information recording layer closer to the laser incidence surface will be referred to as a "first information recording layer").

[0013] Laser light used for recording information on the second information recording layer may become non-uniform when the laser light has passed through a certain area of the first information recording layer. In this case, test recording would not provide accurate recording conditions.

[0014] The light transmittance of an information recording layer varies depending on whether information is recorded or not in the recording and reproduction area of the information recording layer. Therefore, the amount of laser light reaching the second information recording layer varies in accordance with the ratio of an unrecorded area and a recorded area in a light spot of the laser light on the first information recording layer, the light spot being formed before the laser light is used for test recording on the second information recording layer. As a result, accurate recording conditions are not obtained.

[0015] The light transmittance of an unrecorded area in the recording and reproduction area can be considered to be equal to the light transmittance of the reproduction-only area. However, the light transmittance of a recorded area in the recording and reproduction area is different from the light transmittance of the reproduction-only area. Accordingly, when test recording is performed on the second information recording layer, the amount of laser light reaching the second information recording layer varies also in accordance with the ratio of the reproduction-only area and the recording and reproduction area in a light spot on the first information recording layer (and the ratio of the recorded area and the unrecorded area in the recording and reproduction area).

[0016] The second information recording layer is influenced by the state of the first information recording layer when information (for example, user data information) is recorded in a recording and reproduction area of the second information recording layer, as well as at the time of test recording. In this case also, information cannot be accurately recorded, which reduces the signal quality used for reproducing the recorded information.

[0017] The present invention, to solve these problems of the prior art, has an objective of accurately obtaining optimum recording conditions for an optical information recording medium having two or more information recording layers, and another objective of accurately recording information on each of two or more information recording layers of an optical information recording medium.

DISCLOSURE OF THE INVENTION

[0018] An optical information recording medium according to the present invention includes a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer. The first information recording layer includes at least one of a reproduction-only area and a recording and reproduction area. The second information recording layer includes a test recording area. At least one of the reproduction-only area and the recording and reproduction area, and the test recording area is located such that one of the reproduction-only area and the recording and reproduction area includes an area of the first information recording layer through which the laser light for recording information in the test recording area passes.

[0019] The optical information recording medium may further include a separation layer for separating the first information recording layer and the second information recording layer from each other. The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, may extend outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0020] The second information recording layer may have a data recording area which extends from an end of the test recording area by at least the length δ.

[0021] The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, may extend outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/-n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0022] The second information recording layer may

ENSDOCID: <EP_____1318509A1_I_>

include a data recording area which extends from the end of the test recording area by at least the length δ'.

[0023] An optical information recording medium according to the present invention includes a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer. The first information recording layer includes a prescribed area. The second information recording layer includes a test recording area. The prescribed area and the test recording area are located such that the prescribed area includes an area of the first information recording layer through which the laser light for recording information in the test recording area passes. The prescribed area is entirely in a recorded state or entirely in an unrecorded state.

[0024] The prescribed area, when being in an unrecorded state, may be a recording prohibited area.

[0025] The prescribed area, when being in an unrecorded state, may be a mirror area.

[0026] The prescribed area, when being in an unrecorded state, may be a lead-in area.

[0027] The optical information recording medium may further include a separation layer for separating the first information recording layer and the second information recording layer from each other. The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, may extend outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer: n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0028] The second information recording layer may have a data recording area which extends from an end of the test recording area by at least the length δ.

[0029] The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, may extend outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0030] The second information recording layer may include a data recording area which extends from the end of the test recording area by at least the length δ'.

[0031] An optical information recording medium according to the present invention includes a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer. The first information recording layer includes a test recording area and a recording and reproduction area. A light transmittance of an area of the first information recording layer, through which the laser light for recording information in the test recording area passes, is different from a light transmittance of an area of the first information recording layer, through which the laser light for recording information in the recording and reproduction area passes. Information for calculating an optimum recording condition of at least one of the test recording area and the recording and reproduction area is recorded in a specific area of either the first information recording layer or the second information recording layer.

[0032] An optical information recording medium according to the present invention includes a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer. The first information recording layer includes at least one of a reproduction-only area and a first recording and reproduction area. The second information recording layer includes a second recording and reproduction area. At least one of the reproduction-only area and the first recording and reproduction area, and the second recording and reproduction area are located such that one of the reproduction-only area and the first recording and reproduction area includes an area of the first information recording layer through which the laser light for recording information in the second recording and reproduction area passes.

[0033] The optical information recording medium may further include a separation layer for separating the first information recording layer and the second information recording layer from each other. The area of the first information recording layer, through which the laser light for recording information in the second recording and reproduction area passes, may extend outward from an outer end of an area of the first information recording layer corresponding to the second recording and reproduction area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1} NA/n)),$$

where d is a distance in a thickness direction between

3NSDOCID: <EP_____1318509A1_I_>

the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the second recording and reproduction area.

[0034] The area of the first information recording layer, through which the laser light for recording information in the second recording and reproduction area passes, may extend outward from the outer end of the area of the first information recording layer corresponding to the second recording and reproduction area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0035] A size of the reproduction-only area of the first information recording layer may be zero.

[0036] An optical information recording medium according to the present invention includes a first information recording layer on which information is to be recorded by laser light; a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer; and a separation layer for separating the first information recording layer and the second information recording layer from each other. The first information recording layer includes at a first test recording area and a non-uniform light prevention area. The second information recording layer includes a second test recording area. The non-uniform light prevention area, the first test recording area and the second test recording area are located, such that a distance between the first test recording area and the second test recording area is greater than a length δ, and such that the non-uniform light prevention area includes an area of the first information recording layer through which the laser light for recording information in the second test recording area passes, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the second test recording area.

[0037] The first information recording layer may include at least one of a first lead-in area and a first lead-out area. The second information recording layer may include at least one of a second lead-in area and a second lead-out area. The first lead-in area and the second lead-in area respectively may include the first test recording area and the second test recording area, or the first lead-out area and the second lead-out area respectively include the first test recording area and the second test recording area.

[0038] The non-uniform light prevention area of the first information recording layer may be a reproduction-only area.

[0039] The non-uniform light prevention area may be an area formed of at least one of the group consisting of a reproduction-only area, a recording prohibited area, and a mirror area.

[0040] The area of the first information recording layer, through which the laser light for recording information in the second test recording area passes, may extend outward from an outer end of an area of the first information recording layer corresponding to the second test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0041] The area of the first information recording layer, through which the laser light for recording information in the second test recording area passes, may extend outward from an outer end of an area of the first information recording layer corresponding to the second test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0042] An optical information recording method according to the present invention is for an optical information recording medium including a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer. The first information recording layer includes at least one of a reproduction-only area and a recording and reproduction area. The second information recording layer includes a test recording area. The optical information recording method includes the steps of recording information, in advance, in an area of the first information recording layer, through which the laser light for recording information in the test recording area is to pass; and recording the information in the test recording area after the step of recording the information in advance.

[0043] The optical information recording method may

BNSDOCID: <EP 1318509A1 I >

further include a separation layer for separating the first information recording layer and the second information recording layer from each other. The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, may extend outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0044] The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, may extend outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0045] The information which is recorded in advance may be information obtained by modulating dummy information.

[0046] The step of recording the information in advance may include the step of recording using a certification step.

[0047] An optical information recording method according to the present invention is for an optical information recording medium including a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer. The first information recording layer includes at least one of a reproduction-only area and a recording and reproduction area. The second information recording layer includes a test recording area. The optical information recording method includes the steps of determining whether an area of the first information recording layer, through which the laser light for recording information in the test recording area passes, is an area of one of the reproduction-only area and the recording and reproduction area which is an unrecorded state or an area of the recording and reproduction area which is in a recorded state; executing test recording in the test recording area so as to obtain a recording condition; and calculating an optimum recording condition for the second information recording layer based on the result of the determination and the obtained recording condition.

[0048] The optical information recording medium may further include a separation layer for separating the first information recording layer and the second information recording layer from each other. The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, may extend outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the second recording and reproduction area.

[0049] The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, may extend outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0050] The information for calculating the optimum recording condition may be recorded in a specific area of the first information recording layer and the second information recording layer.

[0051] An optical information recording apparatus according to the present invention is for an optical information recording medium including a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer. The second information recording layer includes a test recording area. The optical information recording apparatus includes an interference area determination section for determining an area of the first information recording layer through which the laser light for recording information in the test recording area passes; a recorded/unrecorded state determination section for determining whether the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, is in a recorded state or in an unrecorded state; and a recording

EP 1318509A1 ( )

section for recording a signal in the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, based on the results of the determination of the interference area determination section and the recorded/unrecorded state determination section.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052]

Figure **1** shows an external view of an optical information recording medium according to the present invention.

Figure **2** is a cross-sectional view of the optical information recording medium according to the present invention.

Figure **3** shows a format of a first information recording layer and a second information recording layer according to Example 1 of the present invention.

Figure **4** shows a format of a first information recording layer and a second information recording layer of a comparative example.

Figure **5** shows the length of a light spot of the first information recording layer (i.e., an area of the first information recording layer, through which laser light passes) according to the present invention.

Figure **6** shows a format of a first information recording layer and a second information recording layer according to a modified example of Example 1.

Figure **7** shows a format of a first information recording layer and a second information recording layer according to Example 2 of the present invention.

Figure **8** shows a format of a first information recording layer and a second information recording layer according to Example 3 of the present invention.

Figure **9** is a block diagram of an optical information recording apparatus for creating an optical information recording medium according to Example 3 of the present invention.

Figure **10** shows a format of a first information recording layer and a second information recording layer according to Example 4 of the present invention.

Figure **11** shows a format of a first information recording layer and a second information recording layer according to Example 5 of the present invention.

Figure **12** shows a format of a first information recording layer and a second information recording layer according to Example 6 of the present invention.

Figure **13** shows a format of a plurality of information recording layers according to Example 7 of the present invention.

Figure **14** shows a format of a first information recording layer and a second information recording layer according to Example 8 of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0053] Hereinafter, the present invention will be described by way of illustrative examples with reference to attached drawings.

(Example 1)

[0054] This example relates to an optical information recording medium with which accurate recording conditions can be obtained by the test recording.

[0055] Figure **1** is an external view of an optical information recording medium **100** according to the present invention. Hereinafter, the optical disc **100** will be used as a specific example of the optical information recording medium **100**.

[0056] Figure **2** is a cross-sectional view illustrating a structure of the optical information recording medium or the optical disc **100**. The optical disc **100** has a multilayer structure. As shown in Figure **2**, the optical disc **100** includes an incidence surface **110**, a first information recording layer **120**, a second information recording layer **130**, and a separation layer **150** for separating the first information recording layer **120** and the second information recording layer **130** from each other.

[0057] The first information recording layer **120** and the second information recording layer **130** are formed by pre-forming a groove or a phase pit in a first substrate **140** and a second substrate **145** respectively, and then forming a protective layer, a recording layer, a reflective layer and the like thereon. The resultant first substrate **140** and the resultant second substrate **145** are bonded together with an ultraviolet-curable resin or the like, so as to form the separation layer **150**. The separation layer **150** separates the first information recording layer **120** and the second information recording layer **130** from each other.

[0058] Laser light **170** is focused by an objective lens **160** and then is incident on the incidence surface **110**. The laser light **170** records information on the information recording layers. Figure **2** shows a state where information is recorded on the second information recording layer **130** by the laser light **170** which has passed through the first information recording layer **120**.

BNSDOCID: <EP_____1318509A1_I_>

[0059] Next, a format of the optical disc **100** used in this example will be described.

[0060] Figure **3** shows a format of the first information recording layer **120** and the second information recording layer **130**. Figure **3** shows the format in a radial direction of the disc from the center of the optical disc **100**. The center of the optical disc **100** is represented by "0" in the radial direction. The distance along the arrow labeled as "radial direction" indicates distance from the center of the optical disc **100**. The left side of the figure represents the inner side of the optical disc **100**, and the right side of the figure represents the outer side of the optical disc **100**. In Figure **3**, it is assumed that laser light is directed toward the optical disc **100** from the bottom portion of the figure.

[0061] The first information recording layer **120** includes a first reproduction-only area (ROM) **122** and a first recording and reproduction area (RAM) **124**. The first recording and reproduction area **124** includes a first test recording area (TEST) **126** and a first data recording area (DATA) **128**. In Figure **3**, the first information recording layer **120** includes the first reproduction-only area **122**, the first test recording area **126**, and the first data recording area **128** in that order from the inner portion thereof.

[0062] The second information recording layer **130** includes a second reproduction-only area (ROM) **132** and a second recording and reproduction area (RAM) **134**. The second recording and reproduction area **134** includes a second test recording area (TEST) **136** and a second data recording area (DATA) **138**. An area **133** between the second reproduction-only area **132** and the second test recording area **136** is, for example, an unused area which has not been used. In Figure **3**, the second information recording layer **130** includes the second reproduction-only area **132**, the unused area **133**, the second test recording area **136**, and the second data recording area **138** in that order from the inner portion thereof.

[0063] In the first reproduction-only area **122** and the second reproduction-only area **132**, a phase pit array representing information is formed. In the first recording and reproduction area **124** and the second recording and reproduction area **134**, grooves representing information are formed.

[0064] In this specification, it is assumed that in a reproduction-only area, information which does not need to be rewritten, for example, information of the optical disc itself or address information, is recorded. By contrast, it is also assumed that in a recording and reproduction area, information which has a high possibility of being rewritten is recorded. Since different types of information are recorded in the reproduction-only area and in the recording and reproduction area, the information is recorded in different forms in the reproduction-only area and in the recording and reproduction area as described above. In the reproduction-only area, information which does not need to be rewritten is recorded. Therefore, such information is recorded with a phase pit array, simultaneously with the formation of the substrate. In the recording and reproduction area, information which has a high possibility of being rewritten is recorded. Therefore, information is recorded in the form of a recording mark on the recording layer which is formed on the grooves.

[0065] In this specification, a test recording area is used for performing test recording on the information recording layer including the test recording area. A data recording area is used for recording user data information.

[0066] In this example, the first information recording layer **120** and the second information recording layer **130** are provided from the center of the disc substantially parallel to each other and have substantially the same length as each other.

[0067] Throughout this specification, for easier understanding of the invention, when the optical information recording medium includes two information recording layers, the information recording layer which is closer to the incidence side of the optical information recording medium is referred to as the "first information recording layer" , and the information recording layer which is farther from the incidence side of the optical information recording medium is referred to as the "second information recording layer". As described in detail below, the number of the information recording layers of the optical information recording medium is not limited to two. The present invention is applicable to an optical information recording medium having a plurality of information recording layers.

[0068] Returning to Figure **3**, the format of the optical disc **100** will be described.

[0069] The first recording and reproduction area **124** of the first information recording layer **120** extends from position **r1** to an outer periphery of the optical disc **100**.

[0070] The second test recording area **136** of the second information recording layer **130** extends from position **r2** by distance **a**.

[0071] The start point of the first recording and reproduction area **124** is closer to the center of the disc by length δ than the start point of the second test recording area **136**. In this specification, a "start point" of an area refers to the point in an area having the shortest distance from the center of the disc, and a "termination point" of an area refers to the point in an area having the longest distance from the center of the disc.

[0072] Here, it is assumed that information is recorded in the second test recording area **136** in order to perform test recording of the second information recording layer **130**.

[0073] The laser light **170** for recording information in the second test recording area **136** passes through the first information recording layer **120**. Since the laser light **170** is focused after being incident, an area (light spot) **175** of the first information recording layer, through which the laser light **170** passes, is larger than the sec-

3NSDOCID: <EP_____1318509A1_I_>

ond test recording area **136**. In this example, the optical disc **100** is structured such that the first recording and reproduction area **124** includes the area **175** of the first information recording layer **120** through which the laser light **170** passes for recording information in the second test recording area **136**. For this reason, the start point of the first recording and reproduction layer **124** is closer to the center of the disc by length δ than the start point of the second test recording area **136**. In Figure **3**, only the laser light **170** incident in a portion internal to the second test recording area **136** is considered. The reason is that, since in this structure, the first recording and reproduction area **124** extends from the start point of the first test recording area **126** to the outer periphery of the disc, it is not necessary to consider the laser light **170** incident in a portion external to the second test recording area **136**.

[0074] The length of the area **175** of the first information recording layer **120**, through which the laser light **170** which is to be focused in the second test recording area **136** passes, equals $\delta + \mathbf{a} + \delta$. Namely, the area **175** includes an area corresponding to the second test recording area **136** having the length **a** and two areas respectively extending from an inner end and an outer end of the above-mentioned area toward the center of the disc and the outer periphery of the disc, each extending area having length δ. As described above, such a size of the area **175** results from the fact that the diameter of the spot of the laser light **170** at the first information recording layer **120** is greater than that at the second information recording layer **130**. In the case where the first recording and reproduction area **124** and the second test recording area **136** are located such that the first recording and reproduction area **124** includes at least the area **175**, the laser light **170** passes through only the first recording and reproduction area **124** when passing through the first information recording layer **120** in the test recording performed using the second test recording area **136**.

[0075] As described above, the first recording and reproduction area **124** and the second test recording area **136** are located such that the laser light **170** passes through only the first recording and reproduction area **124** when passing through the first information recording layer **120** in the test recording performed on the second test recording area **136**. The reasons are as follows.

[0076] A recording and reproduction area and a reproduction-only area are formed in different forms. Therefore, the light transmittance of the recording and reproduction area may sometimes be different from the light transmittance of the reproduction-only area. When laser light passes through both the reproduction-only area and the recording and reproduction area in this case, a component of light passing through the reproduction-only area and reaching the second information recording layer and a component of light passing through the recording and reproduction area and reaching the second information recording layer will have different amounts.

[0077] The light transmittance of an unrecorded area in the recording and reproduction area can be considered to be equal to the light transmittance of the reproduction-only area. However, when the recording and reproduction area has information recorded therein, the light transmittance of a recorded area in the recording and reproduction area is different from the light transmittance of the reproduction-only area. Accordingly, when information is recorded in the recording and reproduction area of the first information recording layer, the light transmittance is different between the reproduction-only area **122** and the recording and reproduction area **124** of the first information recording layer **120**.

[0078] In a recording and reproduction area, a recording mark (in an amorphous state) is formed. When the recording mark is formed, the light transmittance of the recording and reproduction area is raised in some cases and is reduced in other cases. Hereinafter, the case where the light transmittance is raised will be described. In this case, the amount of light transmitted through the recording and reproduction area is larger than amount of light transmitted through the reproduction-only area.

[0079] For comparison, Figure **4** shows a format of an optical disc **400** in which a first information recording layer and a second information recording layer have the same format.

[0080] The optical disc **400** includes a first information recording layer **420**, a second information recording layer **430**, and a separation layer **450** for separating the first information recording layer **420** and the second information recording layer **430** from each other.

[0081] The first information recording layer **420** includes a first reproduction-only area (ROM) **422** and a first recording and reproduction area (RAM) **424**. The first recording and reproduction area **424** includes a first test recording area (TEST) **426** and a first data recording area (DATA) **428**.

[0082] The second information recording layer **430** includes a second reproduction-only area (ROM) **432** and a second recording and reproduction area (RAM) **434**. The second recording and reproduction area **434** includes a second test recording area (TEST) **436** and a second data recording area (DATA) **438**.

[0083] In this comparative example, the format of the first information recording layer **420** is the same as that of the second information recording layer **430**. Therefore, the start point **r1'** of the first recording and reproduction area **424** is the same as the start point **r2'** of the second test recording area **436**.

[0084] In this case, when laser light **470** is incident on the innermost portion of the second test recording area **436** (i.e., the left end of the second test recording area **436** as shown in Figure **4**) for test recording of the second information recording layer **430**, half of the laser light **470** incident on the first information recording layer **420** is transmitted through the first reproduction-only area **422**.

NSDOCID: <EP 1318509A1 I >

[0085] As a result, the amount of laser light **470** passing through the first reproduction-only area **422** and reaching the second information recording layer **430** is different from the amount of laser light **470** passing through the first recording and reproduction area **424** and reaching the second information recording layer **430**. Therefore, accurate test recording cannot be performed. For example, when the light transmittance of the recording and reproduction area is higher than the light transmittance of the reproduction-only area, recording power which is greater than the recording power of the laser light passing through the reproduction-only area is determined to be the desired recording power.

[0086] Accordingly, when test recording is performed using the innermost portion of the second test recording area **436** (i.e., the left end of the second test recording area **436** in Figure **4**) in order to obtain the desired recording power, recording power which is greater than the appropriate recording power is provided as the result of the test recording result. Therefore, actual data is recorded at excessively high recording power.

[0087] Moreover, the amount of the laser light **470** reaching the second information recording layer **430** varies in accordance with the ratio of the laser light **470** transmitted through the first reproduction-only area **422** with respect to the entire laser light **470** used for recording information in the second test recording area **436**. As a result, the test recording result varies in accordance with the position of the second test recording area **436** in which information is recorded.

[0088] By contrast, with the format according to this example shown in Figure **3**, the laser light **170** is not influenced by the first reproduction-only area **122** regardless of the position in the second test recording area **136** at which test recording is performed. Accordingly, accurate recording conditions are obtained by the test recording.

[0089] Hereinafter, with reference to Figure **5**, expansion of the light spot **175** on the first information recording layer **120** will be described in detail. Figure **5** shows the length of the light spot **175** on the first information recording laser **120** when the laser light **170** is focused on the second information recording layer **130**. Here, for simpler explanation, the laser light **170** is focused onto a focal point **172** on the second information recording layer **130**. In this state, the angle θ at which the laser light **170** is focused onto the focal point **172** is:

$$\theta = \sin^{-1}(NA/n).$$

[0090] Where the distance in the thickness direction of the disc between the first information recording layer **120** and the second information recording layer **130** is d, the numerical aperture of the objective lens **160** is NA, and the refractive index of the separation layer **150** is n, the radius δ of the light spot **175** on the first information recording layer **120** is represented by:

$$\delta = d \cdot \tan\theta = d \cdot \tan(\sin^{-1}(NA/n)).$$

[0091] From this, as long as the start point of the first test recording area **126** in Figure **3** is away from the start point of the second test recording area **136** by at least length δ represented by the above expression, the first recording and reproduction area **124** includes the light spot **175** of the laser light **170** on the first information recording layer **120**. In this case, accurate recording conditions can be obtained by the test recording.

[0092] As described above, the optical information recording. medium **100** according to this example is structured such that the first recording and reproduction area **124** includes the area **175** of the first information recording layer **120** of the laser light **170** for recording information in the second test recording area **136** passes. Therefore, accurate recording conditions can be obtained by the test recording.

[0093] In Figure **3**, the area between the second reproduction-only area **132** and the second test recording area **136** is the unused area **133**. The present invention is not limited to this.

[0094] For example, as shown in Figure **6**, the unused area **133** may be replaced with a third data recording area **137**. In this case, the length of the data recording area **137** is at least equal to length δ. An optical disc **600** shown in Figure **6** has the same format as that of the optical disc **100** shown in Figure **3** except that the unused area **133** is replaced with the third data recording area **137**. Such a format can expand the data recording area compared to that of the disc **100** shown in Figure **3**.

(Example 2)

[0095] In this example, a case where the center of the two information recording layers are offset with respect to each other will be described.

[0096] In actual production of a multi-layer recording medium, a plurality of information recording layers may be sometimes positionally offset with respect to each other when the information recording layers are bonded together. When the start points of the test recording areas are offset with respect to each other due to the positional offset between the information recording layers, the length δ considered in Example 1 is not sufficient. In this example, the effect of the present invention is provided even when the distances of the two information recording layers from the center of the disc are different from each other.

[0097] Figure **7** shows a format of an optical disc **700** in which a first information recording layer **720** and a second information recording layer **730** are offset with respect to each other by δm.

[0098] The optical disc **700** includes the first information recording layer **720**, the second information recording layer **730**, and a separation layer **750** for separating the first information recording layer **720** and the second

information recording layer **730** from each other.

[0099] The first information recording layer **720** includes a first reproduction-only area (ROM) **722** and a first recording and reproduction area (RAM) **724**. The first recording and reproduction area **724** includes a first test recording area (TEST) **726** and a first data recording area (DATA) **728**. In Figure **7**, the first information recording layer **720** includes the first reproduction-only area **722**, the first test recording area **726**, and the first data recording area **728** in that order from the inner portion thereof.

[0100] The second information recording layer **730** includes a second reproduction-only area (ROM) **732** and a second recording and reproduction area (RAM) **734**. The second information recording layer **730** may include an unused area **733**. The second recording and reproduction area **734** includes a second test recording area (TEST) **736** and a second data recording area (DATA) **738**. In Figure **7**, the second information recording layer **730** includes the second reproduction-only area **732**, the unused area **733**, the second test recording area **736**, and the second data recording area **738** in that order from the inner portion thereof.

[0101] In this figure, the offset δ' between the start points of the first recording and reproduction area **724** and the second test recording area **736**, the offset δ' being defined from the center of the disc, is represented by:

$$\delta' = r2 - r1 = \delta + \delta m = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m.$$

[0102] This represents a value obtained by adding the length δ of the light spot **725** on the first information recording layer **720** described in Example 1 with the length δm of the positional offset between the first information recording layer **720** and the second information recording layer **730**.

[0103] Accordingly, as long as the start of the first recording and reproduction area **724** is away from the start of the second test recording area **736** by at least the length δ' represented by the above expression, the first recording and reproduction area **724** includes a light spot **775** on the first information recording layer **720**, through which laser light **770** passes, even when the first information recording layer **720** and the second information recording layer **730** are positionally offset with respect to each other by the length δm.

[0104] Considering the difference in the distances of the first information recording layer **720** and the second information recording layer **730** from the center of the disc, it is necessary that the first recording and reproduction area **724** includes the area **775**. Here, the area **775** is an area of the first information recording layer **720** through which the laser light **770** used for recording information on the second test recording area **736** passes. The length of the area **775** needs to be at least δ' + **a** + δ'. Namely, the area **775** includes an area corresponding to the second test recording area **736** having the length a and two areas respectively extending from an inner end and an outer end of the above-mentioned area toward the center of the disc and the outer periphery of the disc, each extending area having length δ' . In the case where the first recording and reproduction area **724** and the second test recording area **736** are located such that the first recording and reproduction area **724** includes the area **775**, accurate recording conditions can be obtained by the test recording.

(Example 3)

[0105] In this example, a case where the area of the first information recording layer, through which laser light used for recording information in the test recording area of the second information recording layer passes, is a recorded state area will be described.

[0106] Figure **8** shows a format of an optical disc **800** according to this example.

[0107] The optical disc **800** includes a first information recording layer **820**, a second information recording layer **830**, and a separation layer **850** for separating the first information recording layer **820** and the second information recording layer **830** from each other.

[0108] The first information recording layer **820** includes a first reproduction-only area **822** and a first recording and reproduction area **824**. The first recording and reproduction area **824** includes a first test recording area **826** and a first data recording area **828**. In Figure **8**, the first information recording layer **820** includes the first reproduction-only area **822**, the first test recording area **826**, and the first data recording area **828** in that order from the inner portion thereof.

[0109] The second information recording layer **830** includes a second reproduction-only area **832** and a second recording and reproduction area **834**. The second recording and reproduction area **834** includes a second test recording area **836** and a second data recording area **838**. An area **833** between the second reproduction-only area **832** and the second test recording area **836** is, for example, an unused area which has not been used. In Figure **8**, the second information recording layer **830** includes the second reproduction-only area **832**, an unused area **833**, the second test recording area **836**, and the second data recording area **838** in that order from the inner portion thereof.

[0110] In the optical disc **800**, the first recording and reproduction area **824** includes a recorded state area **875** of the first information recording layer **820**. Laser light **870**, used for recording information in the second test recording area **836**, passes through the recorded state area **875**. The recorded state area **875** is entirely in a recorded state. The length of the recorded state area **875** is δ + a + δ. Namely, the recorded state area **875** includes an area corresponding to the second test recording area **836** having the length **a** and two areas respectively extending from an inner end and an outer end of the above-mentioned area toward the center of the

VSDOCID: <EP_____1318509A1_I_>

disc and the outer periphery of the disc, each extending area having length δ.

[0111] The recorded state area **875** is formed by recording information in the entirety of the recorded state area **875** of the first recording and reproduction area **824**, for example, before the second test recording area **836** is used.

[0112] Owing to such a structure, onto whichever position of the second test recording area **836** the laser light **870** may be focused, the light transmittance of the area of the first recording and reproduction area **824**, through which the laser light **870** passes (i.e., area **875**), can be uniform. The light transmittance varies depending on whether information is recorded or not in the recording and reproduction area **824**. Since the area **875** is entirely in a recorded state, the light transmittance is uniform. Accordingly, as long as information is recorded in the recorded state area **875** shown in Figure **8**, the amount of the laser light **870** reaching the second test recording area **836** is uniform when test recording is performed on the second test recording area **836**. As a result, accurate recording conditions can be obtained.

[0113] In this example, when the first information recording layer **820** and the second information recording layer **830** are positionally offset with respect to each other, the length of the recorded state area **875** may have the length δ' + **a** + δ' as described in Example 2.

[0114] The information to be recorded in the recorded state area **875** may be information obtained by modulating data information or information obtained by modulating dummy information.

[0115] It is preferable to record information in the recorded state area **875** at the time of certification after the optical disc is produced. Since the recording apparatus does not need to perform this step, the start time when a new optical disc is mounted on the recording apparatus can be shortened.

[0116] Next, an optical recording apparatus for recording information on the optical information recording medium according to this example will be described.

[0117] Figure **9** shows an optical information recording apparatus **900** for creating the optical information recording medium according to this example. Hereinafter, an operation of the optical information recording apparatus **900** will be described with reference to Figure **9**.

[0118] The optical information recording apparatus **900** includes a spindle motor **907** for rotating the optical disc **800** and an optical head **903** including a laser source (not shown) and focusing laser light to a desired position of an information recording layer of the optical disc **800**. The entire operation of the optical information recording apparatus **900** is controlled by a system control section **901**. It is not intended that the recorded state area **875** of the optical disc **800** is in a completely recorded state at this point.

[0119] The optical information recording apparatus **900** further includes a recording section **902** for modulating the light intensity of the laser source in the optical head **903** based on information obtained by modulating data information, and a reproduction section **904** for performing waveform processing of a reproduction signal based on the light reflected by the optical disc **800** so as to demodulate reproduction information. The optical information recording apparatus **900** also includes an interference area determination section **905** for determining whether or not a given area of the first information recording layer **820** is an area which can be an optical path of the laser light **870** for recording information in the second test recording area **836** (i.e., whether or not the given area is the area **875** through which the laser light passes for recording information in the second test recording area **836**), and a recorded/unrecorded state determination section **906** for reproducing the information in the area **875** through which the laser light passes for recording information in the second test recording area **836** and then determining whether the area **875** is in a recorded state or an unrecorded state based on the reproduction result.

[0120] Hereinafter, with reference to Figures **8** and **9**, operation of the optical information recording apparatus **900** according to this example will be described. First, the system control circuit **901** rotates the spindle motor **907**, and the optical head **903** focuses the laser light **870** onto the first information recording layer **820** on the optical disc **800** so as to reproduce information on the first information recording layer **820**. Based on address reproduction information from the reproduction section **904**, the interference area determination section **905** determines whether the area, in which information is being reproduced, is the area **875** or not. Based on the determination result, the system control section **901** seeks for the optical head **903** up to a certain area in the area **875** and reproduces information in the certain area of the area **875**.

[0121] Based on the reproduction information from the reproduction section **904**, the recorded/unrecorded state determination section **906** determines whether the track in the certain area in the area **875**, in which information is being reproduced, is in a recorded state or an unrecorded state. When the recorded/unrecorded state determination section **906** determines that the track is in an unrecorded state, some information is recorded in the track in the certain area in the area **875** so as to place the certain area in the area **875** into a recorded state. When the recorded/unrecorded state determination section **906** determines that the track is in a recorded state, it is confirmed that the certain area in the area **875**, in which information is being reproduced, is already in a recorded state. This operation is performed for the entirety of the area **875**.

[0122] In this manner, the area **875** is entirely placed into a recorded state, and thus acts as a recorded state area. Onto whichever position of the second test recording area **836** the laser light **870** may be focused, the light transmittance of the area **875** of the first information recording layer **820**, through which the laser light for re-

cording information in the second test recording area **836** passes, can be uniform. Accordingly, whichever portion of the second test recording area **836** of the second information recording layer may be used for test recording, the amount of the laser light reaching the second test recording area **836** is the same. Thus, accurate recording conditions can be obtained.

(Example 4)

[0123] In Example 3, an operation for placing the area **875**, of the first information recording layer, through which the laser light for recording information in the second test recording area **836** passes, into a recorded state area was described. In this example, a specific example of an operation for placing the entirety of the area of the first information recording layer, through which the laser light for recording information in the second test recording area passes, into an unrecorded state will be described.

[0124] Figure **10** shows a format of an optical disc **1000** according to Example 4.

[0125] The optical disc **1000** includes a first information recording layer **1020**, a second information recording layer **1030**, and a separation layer **1050** for separating the first information recording layer **1020** and the second information recording layer **1030** from each other.

[0126] The first information recording layer **1020** includes a first reproduction-only area **1022** and a first recording and reproduction area **1024**. The first recording and reproduction area **1024** includes a first test recording area **1026** and a first data recording area **1028**. In Figure **10**, the first information recording layer **1020** includes the first reproduction-only area **1022**, the first test recording area **1026**, and the first data recording area **1028** in that order from the inner portion thereof.

[0127] The second information recording layer **1030** includes a second reproduction-only area **1032** and a second recording and reproduction area **1034**. The second recording and reproduction area **1034** includes a second test recording area **1036** and a second data recording area **1038**. An area **1033** between the second reproduction-only area **1032** and the second test recording area **1036** is, for example, an unused area which has not been used. In Figure **10**, the second information recording layer **1030** includes the second reproduction-only area **1032**, the unused area **1033**, the second test recording area **1036**, and the second data recording area **1038** in that order from the inner portion thereof.

[0128] In the optical disc **1000**, the first recording and reproduction area **1024** includes a unrecorded state area **1075** of the first information recording layer **1020**. Laser light **1070**, used for recording information in the second test recording area **1036**, passes through the unrecorded state area **1075**. The unrecorded state area **1075** is entirely in an unrecorded state. The length of the unrecorded state area **1075** is $\delta + \mathbf{a} + \delta$. Namely, the recorded state area **1075** includes an area corresponding to the second test recording area **1036** having the length a and two areas respectively extending from an inner end and an outer end of the above-mentioned area toward the center of the disc and the outer periphery of the disc, each extending area having length δ.

[0129] As shown in Figure **10**, the area, of the first recording and reproduction area **1024** including the area corresponding to the second test recording area **1036** having the length **a** and two areas respectively extending from an inner end and an outer end of the above-mentioned area toward the center of the disc and the outer periphery of the disc, each extending area having length δ (i.e., the area of the first information recording layer **1020** having the length of $\delta + \mathbf{a} + \delta$) is in an unrecorded state at the time of test recording.

[0130] The information for calculating optimum recording conditions based on the result of the test recording may be recorded in an arbitrary area of the first information recording layer **1020** and the second information recording layer **1030**. In this case, the information for calculating the optimum recording conditions are, for example, information for multiplying the recording conditions in an unrecorded state by a certain coefficient based on, for example, the difference in the amount of transmitted light between the unrecorded state and the recorded state. In this example, the entirety of the area of the first information recording layer **1020**, through which the laser light for recording information in the second test recording area **1036** passes, is in an unrecorded state. Accordingly, the recording conditions obtained in such a circumstance have a possibility of not being optimum for recording information in the second test recording area **1038** using the laser light which has passed through the first recording information recording layer **1020** having information recorded thereon.

[0131] Hereinafter, a specific example of an operation for multiplying the recording conditions in an unrecorded state by a certain coefficient based on the difference in the amount of transmitted light between the unrecorded state and the recorded state will be described.

[0132] In the case of an optical disc in which the amount of transmitted light in a recorded state is s times the amount of transmitted light in an unrecorded state, where the optimum recording power obtained by performing test recording in an unrecorded state is Pm, the optimum recording power Pk in a recorded state can be calculated as follows.

$$Pk = Pm/s$$

[0133] Here, "s" is defined as the transmittance correction coefficient. By such a calculation, even when information is not recorded in a specific area of the first information recording layer **1020** in advance, the optimum recording power in the case where the area of the

INSDOCID: <EP_____1318509A1_I_>

first information recording layer **1020**, through which the laser light passes, is in a recorded state can be estimated. In the case where it is time-consuming to form the recorded state area **875** in the first information recording layer **1020** as in Example 3, the optimum recording conditions can be calculated as in this example, instead of directly obtaining the optimum recording conditions as in Example 3.

[0134] In the case where there is a possibility that the first information recording layer **1020** and the second information recording layer **1030** in this example are positionally offset with respect to each other, it is preferable to keep the unrecorded state area **1075** having the length $\delta' + \mathbf{a} + \delta'$ unrecorded at the time of test recording as described in Example 2.

[0135] In this example, it is more preferable to record the transmittance correction coefficient s for determining the optimum recording power in a specific area in the optical disc **1000** (for example, the first reproduction-only area **1022** or the second reproduction-only area **1032**). In this case, even when the transmittance correction coefficient is different among different optical discs, the optical disc recording apparatus can immediately learn the coefficient when an optical disc is mounted on the optical disc recording apparatus. Therefore, the time required to start actually recording information can be shortened.

[0136] In this example, the unrecorded state area at the time of test recording may be a recording prohibited area where information is never recorded. Alternatively, the unrecorded state area may be a mirror area which does not have any guide grooves for tracking servo control.

(Example 5)

[0137] In Examples 1 through 4, the recording and reproduction area of the first information recording layer includes a light spot of the laser light. The present invention is not limited to such a format. In this example, a format where the reproduction-only area of the first information recording layer includes a light spot of the laser light will be described.

[0138] Figure **11** shows a format of an optical disc **1100** according to Example 5.

[0139] The optical disc **1100** includes a first information recording layer **1120**, a second information recording layer **1130**, and a separation layer **1150** for separating the first information recording layer **1120** and the second information recording layer **1130** from each other.

[0140] The first information recording layer **1120** includes a first reproduction-only area **1122** and a first recording and reproduction area **1124**. The first recording and reproduction area **1124** includes a first test recording area **1126** and a first data recording area **1128**. In Figure **11**, the first information recording layer **1120** includes the first reproduction-only area **1122**, the first test recording area **1126**, and the first data recording area **1128** in that order from the inner portion thereof.

[0141] The second information recording layer **1130** includes a second reproduction-only area **1132**, a third reproduction-only area **1133**, and a second recording and reproduction area **1134**. The second recording and reproduction area **1134** includes a second test recording area **1136** and a second data recording area **1138**. In Figure **11**, the second information recording layer **1130** includes the second reproduction-only area **1132**, the second test recording area **1136**, the third reproduction-only area **1133**, and the second data recording area **1138** in that order from the inner portion thereof.

[0142] As shown in Figure **11**, the first reproduction-only area **1122** of the first information recording layer **1120** is structured so as to include an area (light spot) **1175** through which laser light **1170** for recording information in the second test recording area **1136** passes. The length of the area **1175** is $\delta + \mathbf{a} + \delta$. Namely, the area **1175** includes an area corresponding to the second test recording area **1136** having the length a and two areas respectively extending from an inner end and an outer end of the above-mentioned area toward the center of the disc and the outer periphery of the disc, each extending area having length δ. Thus, at whichever position of the second test recording area **1136** test recording may be performed, the laser light for recording information in the second test recording area **1136** is the laser light which has passed through the first reproduction-only area **1122**. As a result, the recording conditions are prevented from being dispersed depending on the position at which the test recording is performed.

[0143] In this example, as described in Example 4, it is more preferable to calculate the optimum recording conditions based on the result of the test recording. Thus, the optimum recording conditions for the case where the laser light passes through the first recording and reproduction area **1124**, which is in a recorded state with a recording mark array being formed, can be estimated.

[0144] In the case where there is a possibility that the first information recording layer **1120** and the second information recording layer **1130** are positionally offset with respect to each other, the first reproduction-only area **1122** is located so as to have the length $\delta' + \mathbf{a} + \delta'$, which is the length of the area **1175** of the first information recording layer **1120**, as described in Example 2.

(Example 6)

[0145] In Examples 1 through 5, information is recorded in the test recording area of the second information recording layer in order to perform test recording of the second information recording layer. When data is recorded in the recording and reproduction area of the second information recording layer, as well as at the time of test recording described in Examples 1 through 5, there is a possibility of the signal quality for reproduc-

EPODOC: EP 1318509A1 >

ing the recorded signal being lowered. The reason is that when the laser light used for recording passes through both the reproduction-only area and the recording and reproduction area, the amount of laser light reaching the recording and reproduction area of the second information recording layer is different depending on which one of the above two areas the laser light has passed through. As a result, accurate recording cannot be performed.

[0146] In this example, a specific example of recording information in the recording and reproduction area of the second information recording layer will be described.

[0147] Figure **12** shows a format of an optical disc **1200** according to Example 6.

[0148] The optical disc **1200** includes a first information recording layer **1220**, a second information recording layer **1230**, and a separation layer **1250** for separating the first information recording layer **1220** and the second information recording layer **1230** from each other.

[0149] The first information recording layer **1220** includes a first reproduction-only area **1222** and a first recording and reproduction area **1224**. In Figure **12**, the first information recording layer **1220** includes the first reproduction-only area **1222** and the first recording and reproduction area **1224** in that order from the inner portion thereof.

[0150] The second information recording layer **1230** includes a second reproduction-only area **1232** and a second recording and reproduction area **1234**. In Figure **12**, the second information recording layer **1230** includes the second reproduction-only area **1232** and the second recording and reproduction area **1234** in that order from the inner portion thereof.

[0151] As shown in Figure **12**, the first reproduction-only area **1222** is preferably smaller than the second reproduction-only area **1232** of the second information recording layer **1230**.

[0152] In Figure **12**, the start point of the first recording and reproduction area **1224** is located closer to the center of the disc than the start point of the second recording and reproduction area **1234** by length δ. Owing to such a structure, in whichever portion of the second recording and reproduction area **1234** information may be recorded, the first recording and reproduction area **1224** includes an area **1275** of the first information recording layer **1220** through which the laser light for recording information in the second recording and reproduction area **1234** passes. Therefore, the second recording and reproduction area **1234** is only influenced by the first recording and reproduction area **1224** and is not influenced by the first reproduction-only area **1222**. Thus, information can be accurately recorded in the second recording and reproduction area **1234**.

[0153] In the case where there is a possibility that the first information recording layer **1220** and the second information recording layer **1230** are positionally offset with respect to each other, the start point of the first recording and reproduction area **1224** and the start point of the second recording and reproduction area **1234** are preferably offset with respect to each other by δ' as described in Example 2.

[0154] In Figure **12**, the size of the first reproduction-only area **1222** may be zero. In this case, it is not necessary to form a phase pit for the first reproduction-only area **1222** at the time of production of the first information recording layer **1200**. Thus, the production process of the disc can be simplified.

(Example 7)

[0155] In Examples 1 through **6**, there are two information recording layers. The present invention is not limited to this. According to the present invention, the number of information recording layers may be three or more.

[0156] Figure **13** shows a format of an optical disc **1300** according to Example 7 of the present invention.

[0157] The optical disc **1300** is obtained by expanding the optical disc in Example 1, and has a different format from that of the optical disc in Example 1. The optical disc **1300** includes N number of information recording layers. In Figure **13**, among the N number of information recording layers, three information recording layers **i**, **j** and **k** each have a reproduction area in order to obtain accurate recording conditions by the test recording.

[0158] In this example, a first information recording layer **1310** is the i'th layer, a second information recording layer **1320** is the j'th layer, a third information recording layer **1330** is the k'th layer, from the laser incidence side of the disc. The distance between the first information recording layer **1310** and the second information recording layer **1320** is dij, the distance between the second information recording layer **1320** and the third information recording layer **1330** is djk, and distance between the first information recording layer **1310** and the third information recording layer **1330** is dik.

[0159] The first information recording layer **1310** includes a first reproduction-only area **1312** and a first recording and reproduction area **1314**. The first recording and reproduction area **1314** includes a first test recording area **1316** and a first data recording area **1318**.

[0160] The second information recording layer **1320** includes a second reproduction-only area **1322** and a second recording and reproduction area **1324**. The second recording and reproduction area **1324** includes a second test recording area **1326** and a second data recording area **1328**.

[0161] The third information recording layer **1330** includes a third reproduction-only area **1332** and a third recording and reproduction area **1334**. The third recording and reproduction area **1334** includes a third test recording area **1336** and a third data recording area **1338**.

[0162] In this case, the start point of the first recording and reproduction area **1312** is at least δij away from the

3NSDOCID: <EP_____1318509A1_I_>

start point of the second test recording area **1326**, and is at least δik away from the start point of the third test recording area **1336**. The start point of the second recording and reproduction area **1324** is at least δjk away from the start point of the third test recording area **1336**. Here,

$$\delta ij = dij \cdot \tan(\sin^{-1} NA/n)),$$

$$\delta ik = dik \cdot \tan(\sin^{-1}(NA/n)), \text{ and}$$

$$\delta jk = djk \cdot \tan(\sin^{-1}(NA/n)),$$

where NA is the numerical aperture of an objective lens for focusing laser light **1370**, and n is the refractive index of the separation layer between the first information recording layer **1310** and the second information recording layer **1320** and of the separation layer between the second information recording layer **1320** and the third information recording layer **1330**.

[0163] Owing to such a structure, the laser light **1370** for recording information in the second test recording area **1326** passes through only the first recording and reproduction area **1314** when passing through the first information recording layer **1310**. The laser light **1370** for recording information in the third test recording area **1336** passes through only the first recording and reproduction area **1314** when passing through the first information recording layer **1310** and only the second recording and reproduction area **1324** when passing through the second information recording layer **1320**.

[0164] Even when the information recording layer as a target is, for example, between the first information recording layer **1310** and the second information recording layer **1320** as in this example or at an arbitrary position, substantially the same effect as that in Example 1 is provided, as long as the second information recording layer **1320** is farther from the incidence surface than the first information recording layer **1310**, and an area of the first information recording layer **1310**, through which the laser light **1370** for recording information in the second test recording area **1326** passes, is entirely a recording and reproduction area.

(Example 8)

[0165] Figure **14** shows a format of an optical disc **1400** according to Example 8 of the present invention.

[0166] The optical disc **1400** includes a first information recording layer **1420**, a second information recording layer **1430**, and a separation layer **1450** for separating the first information recording layer **1420** and the second information recording layer **1430** from each other.

[0167] The first information recording layer **1420** includes a first reproduction-only area **1422**, a first recording and reproduction area **1424** and a second reproduction-only area **1429**. The first recording and reproduction area **1424** includes a first test recording area **1426** and a first data recording area **1428**. In Figure **14**, the first information recording layer **1420** includes the first test recording area **1426**, the first reproduction-only area **1422**, the first data recording area **1428**, and the second reproduction-only area **1429** in that order from the inner portion thereof. The first information recording layer **1420** includes a first lead-in area **1425** and a first lead-out area **1427**. The first lead-in area **1425** includes the first test recording area **1426** and the first reproduction-only area **1422**. The first lead-out area **1427** includes the second reproduction-only area **1429**.

[0168] The second information recording layer **1430** includes a third reproduction-only area **1432**, a second recording and reproduction area **1434**, a fourth reproduction-only area **1433**, and a fifth reproduction-only area **1439**. The second recording and reproduction area **1434** includes a second test recording area **1436** and a second data recording area **1438**. In Figure **14**, the second information recording layer **1430** includes the third reproduction-only area **1432**, the second test recording area **1436**, the fourth reproduction-only area **1433**, the second data recording area **1438**, and the fifth reproduction-only area **1439** in that order from the inner portion thereof. The second information recording layer **1430** includes a second lead-in area **1435** and a second lead-out area **1437**. The second lead-in area **1435** includes the third reproduction-only area **1432**, the second test recording area **1436**, and the fourth reproduction-only area **1433**. The second lead-out area **1437** includes the fifth reproduction-only area **1439**.

[0169] In this example, when priority is put on easy management of the optical disc **1400**, it is preferable to have the format shown in Figure **14** in which the first data recording area **1428** and the second data recording area **1438** have an equal size. The optical disc **1400** includes the first lead-in area **1425** and the second lead-in area **1435** internally to the first data recording area **1428** and the second data recording area **1438**, respectively. The optical disc **1400** also includes the first lead-out area **1427** and the second lead-out area **1439** externally to the first data recording area **1428** and the second data recording area **1438**, respectively. The first test recording area **1426** is located internally to the first lead-in area **1425**, and the second test recording area **1436** is located internally to the second lead-in area **1435**.

[0170] The first test recording area **1426** and the second test recording area **1436** are positionally offset with respect to each other by length δ or more. The first reproduction-only area **1422** includes a non-uniform light prevention area **1475** of the first information recording layer **1410** through which laser light **1470** for recording information in the second test recording area **1436** passes. The length of the area **1475** is represented by δ + **a** + δ. The non-uniform light prevention area **1475** pre-

EPNSDOCID: <EP 1318509A1 I >

vents the laser light **1470** incident thereon from transmitting therethrough in a non-uniform shape.

[0171] The non-uniform light prevention area **1475** is, for example, a reproduction-only area.

[0172] Alternatively, the non-uniform light prevention area **1475** may be a recording prohibited area or a mirror area. Owing to such a structure, at whichever position of the second test recording area **1436** test recording may be performed, the obtained recording conditions are not dispersed. Moreover, owing to such a structure, the first lead-in area **1425** of the first information recording layer **1420** and the second lead-in area **1435** of the second information recording layer **1430** can have identical start points, termination points and capacities. The first data recording area **1428** of the first information recording layer **1420** and the second data recording area **1438** of the second information recording layer **1430** can have identical start points, termination points and capacities. The first lead-out area **1427** of the first information recording layer **1420** and the second lead-out area **1437** of the second information recording layer **1430** can have identical start points, termination points and capacities. Therefore, defect management and recording information management of the optical disc **1400** are advantageously easy. Substantially the same effect is provided when the first test recording area **1426** is located in the first lead-out area **1427** and the second test recording area **1436** is located in the second lead-out area **1437**.

[0173] The positions of the areas and the shape of the disc used in the above examples are not limited to those described above, and may be of any appropriate form in accordance with the medium itself or the recording and reproduction apparatus.

INDUSTRIAL APPLICABILITY

[0174] As described above, according to an optical information recording medium of the present invention, an area of the first information recording layer, through which laser light passes, is entirely placed into a recorded state or an unrecorded state at the time of test recording of the second information recording layer. Therefore, accurate recording conditions can be obtained by the test recording.

[0175] According to an optical information recording medium of the present invention, an area of the first information recording layer, through which laser light passes, is entirely placed into a reproduction-only area or a recording and reproduction area at the time of test recording of the second information recording layer. Therefore, accurate recording conditions can be obtained by the test recording.

[0176] According to an optical information recording medium of the present invention, the reproduction-only area of the first information recording layer is made smaller than the reproduction-only area of the second information recording layer. Therefore, information can be accurately recorded anywhere in the recording and reproduction area of the second information recording layer.

[0177] According to an optical information recording medium of the present invention, when recording information in the recording and reproduction area of the second information recording layer, an area of the first information recording layer, through which laser light passes, is entirely placed into a reproduction-only area or a recording and reproduction area. Therefore, information can be accurately recorded in the recording and reproduction area.

[0178] According to an optical information recording method of the present invention, information is recorded in an area of the recording and reproduction area of the first information recording layer through which laser light passes before test recording of the second information recording layer. Therefore, accurate recording conditions can be obtained by the test recording.

[0179] According to a recording and reproduction method of the present invention, in the case where an area of the recording and reproduction area of the first information recording layer through which laser light passes is in an unrecorded state at the time of test recording of the second information recording layer, optimum recording conditions are calculated based on the test recording result. Therefore, accurate recording conditions can be obtained.

[0180] In a medium according to the present invention, one of the reproduction-only area and the recording and reproduction area of the first information recording layer includes an area through which laser light for recording information in the test recording area of the second information recording layer passes. The laser light for recording information in the test recording area of the second information recording layer has passed through the reproduction-only area or the recording and reproduction area. Accordingly, the laser light for recording information in the test recording area of the second information recording layer is not influenced by the difference between the amount of light passing through the reproduction-only area of the first information recording layer and the amount of light passing through the recording and reproduction area of the first information recording layer. As a result, accurate recording conditions can be obtained using the test recording area of the second information recording layer.

[0181] The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between

3NSDOCID: <EP 1318509A1 I >

the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0182] The area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0183] Accordingly, even when there is a non-negligible offset or eccentricity in the relative positions of the information recording layers, accurate recording conditions for the second information recording layer can be obtained at the time of test recording of the second information recording layer, with no influence of the difference in the amount of light passing through the first information recording layer.

[0184] It is preferable to form an area of the second information recording laser, extending from the end of at least the test recording area by δ (in the case where there is a non-negligible offset or eccentricity in the relative positions of the information recording layers, by δ') into a data recording area. This is preferable in order to expand the data recording area.

[0185] According to the medium of the present invention, a prescribed area of the first information recording layer, which is entirely in a recorded state or an unrecorded state, includes an area through which the laser light for recording information in the test recording area of the second information recording layer passes. The area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, is entirely either in a recorded state or in an unrecorded state. Accordingly, the laser light for recording information in the test recording area of the second information recording layer is not influenced by the difference in the amount of light caused by the existence of both a recorded state area and an unrecorded state area. As a result, accurate recording conditions can be obtained using the test recording area of the second information recording layer.

[0186] The prescribed area which is entirely in an unrecorded area is, for example, a recording prohibited area, a mirror area, or a lead-in area.

[0187] Regarding a second optical information recording medium according to the present invention, the area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0188] Regarding the second optical information recording medium according to the present invention, the area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0189] Owing to such a medium, even when there is a non-negligible offset or eccentricity in the relative positions of the information recording layers, accurate recording conditions for the second information recording layer can be obtained at the time of test recording of the second information recording layer, with no influence of the difference in the amount of light passing through the first information recording layer.

[0190] Regarding the second optical information recording medium according to the present invention, it is preferable to form an area of the second information recording laser, extending from the end of at least the test recording area by δ (in the case where there is a non-negligible offset or eccentricity in the relative positions of the information recording layers, by δ') into a data recording area. This is preferable in order to expand the data recording area.

[0191] The information for calculating the optimum recording conditions in the test recording area are recorded in a specific area of one of a plurality of recording information layers. Accordingly, even when the transmittance of the area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, is different from the transmittance of the area of the first recording information layer, through which the laser light for recording information in the re-

INSDOCID: <EP 1318509A1 I >

cording and reproduction area of the second information recording layer passes, accurate recording conditions can be calculated for one of the layers as long as the recording conditions of the other layer can be obtained. As a result, a recording and reproduction apparatus for starting the optical information recording medium can immediately learn a method of calculation which is determined from the difference between the amount of light transmitted through an unrecorded state area and the amount of light transmitted through a recorded state area. Accordingly, accurate recording conditions can be obtained immediately after the optical information recording medium is mounted on the recording and reproduction apparatus.

[0192] According to this medium, one of the reproduction-only area and the recording and reproduction area of the first information recording layer includes an area through which laser light for recording information in the recording and reproduction area of the second information recording layer passes. The laser light for recording information in the recording and reproduction area of the second information recording layer has passed through the reproduction-only area or the recording and reproduction area. Accordingly, the laser light for recording information in the recording and reproduction area of the second information recording layer is not influenced by the difference between the amount of light passing through the reproduction-only area of the first information recording layer and the amount of light passing through the recording and reproduction area of the first information recording layer. As a result, accurate recording conditions can be obtained using the recording and reproduction area of the second information recording layer.

[0193] The area of the first information recording layer, through which the laser light for recording information in the recording and reproduction area of the second information recording layer passes, extends outward from an outer end of an area of the first information recording layer corresponding to the recording and reproduction area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1} NA/n)).$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer: and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0194] The area of the first information recording layer, through which the laser light for recording information in the recording and reproduction area of the second information recording layer passes, extends outward from the outer end of the area of the first information recording layer corresponding to the recording and reproduction area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0195] In an optical information recording and reproduction medium according to the present invention, the size of the reproduction-only area of the first information recording layer can be zero, such that an area influenced by the reproduction-only area of the first information recording layer is minimized at the time of recording in the recording and reproduction area of the second information recording layer. Thus, information can be recorded accurately on the second information recording layer.

[0196] Owing to this medium, the necessity of forming a phase pit in the reproduction-only area at the time of production of the first information recording layer is eliminated. Thus, the production process of the disc substrate can be simplified.

[0197] The lead-in areas or the lead-out areas of corresponding information recording layers include a first test recording area, a recording and reproduction area, and a second test recording area. Therefore, recording conditions of different information recording layers can be obtained with only the lead-in areas or the lead-out areas. In this case, the non-uniform light prevention area of the first information recording layer includes an area of the first information recording layer through which laser light for recording information in the test recording area of the second information recording layer passes.

[0198] The non-uniform light prevention area is, for example, a reproduction-only area.

[0199] The non-uniform light prevention area is, for example, an area formed of at least one of the group consisting of a reproduction-only area, a recording prohibited area, and a mirror area.

[0200] The area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0201] The area of the first information recording lay-

NSDOCID: <EP_____1318509A1_I_>

er, through which the laser light for recording information in the test recording area of the second information recording layer passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0202] Accordingly, even when there is a non-negligible offset or eccentricity in the relative positions of the information recording layers, accurate recording conditions for the second information recording layer can be obtained at the time of test recording of the second information recording layer, with no influence of the difference in the amount of light passing through the first information recording layer.

[0203] According to the method of the present invention, before information is recorded in the test recording area of the second information recording layer, information is stored in an area of the first information recording layer through which laser light for recording information in the test recording area of the second information recording layer passes. Accordingly, the laser light for recording information in the test recording area of the second information recording layer is not influenced by the difference in the amount of light which is caused by the first information recording layer having both a recorded state area and an unrecorded state area. As a result, accurate recording conditions can be obtained by test recording of the second information recording layer.

[0204] The area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0205] The area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

[0206] Owing to such a method, even when there is a non-negligible offset or eccentricity in the relative positions of the information recording layers, accurate recording conditions can be obtained at the time of test recording of the second information recording layer, with no influence of the difference in the amount of light caused by the first information recording layer having both a recorded state area and an unrecorded state area.

[0207] The information which is recorded in advance may be, for example, information obtained by modulating dummy information.

[0208] The information may be recorded in advance by a certification step.

[0209] According to the method of the present invention, optimum recording conditions for the second information recording layer can be calculated based on the function and/or the state of the area of the first information recording layer through which the laser light for recording information in the test recording area of the second information recording layer passes.

[0210] The area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

[0211] The area of the first information recording layer, through which the laser light for recording information in the test recording area of the second information recording layer passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance be-

3NSDOCID: <EP 1318509A1 I >

tween the first information recording layer and the second information recording layer.

[0212] Owing to this method, even when there is a non-negligible offset or eccentricity in the relative positions of the information recording layers, accurate recording conditions can be obtained at the time of test recording of the second information recording layer, based on the difference between the amount of light transmitted through an unrecorded state area of the first information recording layer and the amount of light transmitted through a recorded state area of the first information recording layer.

[0213] It is preferable to record information for calculating the optimum recording conditions in a specific area of the optical information recording medium.

[0214] Thus, even when the method of calculation is different medium by medium, the recording and reproduction apparatus can immediately learn the method of calculation. Therefore, the time required for actually recording information after the medium is mounted on the apparatus can be shortened.

[0215] According to the optical information recording apparatus of the present invention, even when an area of the first information recording layer, through which laser light for recording information in the test recording area of the second information recording layer passes, includes an unrecorded state area, the laser light for recording information in the test recording area of the second information recording layer records the information in the area of the first information recording layer, before recording the information in the test recording area of the second information recording layer. Therefore, there is no influence of the difference in the amount of light, caused by the laser light for recording information in the test recording area of the second information recording layer passing through an area including both a recorded state area and an unrecorded state area. As a result, accurate recording conditions for the second information recording layer can be obtained.

Claims

1. An optical information recording medium, comprising:

   a first information recording layer on which information is to be recorded by laser light; and
   a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer,

   wherein:

   the first information recording layer includes at least one of a reproduction-only area and a recording and reproduction area,

   the second information recording layer includes a test recording area, and
   at least one of the reproduction-only area and the recording and reproduction area, and the test recording area is located such that one of the reproduction-only area and the recording and reproduction area includes an area of the first information recording layer through which the laser light for recording information in the test recording area passes.

2. An optical information recording medium according to claim 1, further comprising a separation layer for separating the first information recording layer and the second information recording layer from each other,
   wherein:

   the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

   where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

3. An optical information recording medium according to claim 2, wherein the second information recording layer has a data recording area which extends from an end of the test recording area by at least the length δ.

4. An optical information recording medium according to claim 2, wherein the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

   where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

SDOCID: <EP_____1318509A1_I_>

5. An optical information recording medium according to claim 4, wherein the second information recording layer includes a data recording area which extends from the end of the test recording area by at least the length δ'.

6. An optical information recording medium, comprising:

a first information recording layer on which information is to be recorded by laser light; and
a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer,

wherein:

the first information recording layer includes a prescribed area,
the second information recording layer includes a test recording area,
the prescribed area and the test recording area are located such that the prescribed area includes an area of the first information recording layer through which the laser light for recording information in the test recording area passes, and
the prescribed area is entirely in a recorded state or entirely in an unrecorded state.

7. An optical information recording medium according to claim 6, wherein the prescribed area, when being in an unrecorded state, is a recording prohibited area.

8. An optical information recording medium according to claim 6, wherein the prescribed area, when being in an unrecorded state, is a mirror area.

9. An optical information recording medium according to claim 6, wherein the prescribed area, when being in an unrecorded state, is a lead-in area.

10. An optical information recording medium according to claim 6, further comprising a separation layer for separating the first information recording layer and the second information recording layer from each other,
wherein:

the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

11. An optical information recording medium according to claim 10, wherein the second information recording layer has a data recording area which extends from an end of the test recording area by at least the length δ.

12. An optical information recording medium according to claim 10, wherein the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

13. An optical information recording medium according to claim 12, wherein the second information recording layer includes a data recording area which extends from the end of the test recording area by at least the length δ'.

14. An optical information recording medium, comprising:

a first information recording layer on which information is to be recorded by laser light; and
a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer,

wherein:

the first information recording layer includes a test recording area and a recording and reproduction area,
a light transmittance of an area of the first information recording layer, through which the laser light for recording information in the test recording area passes, is different from a light transmittance of an area of the first information re-

INSDOCID: <EP 1318509A1 I >

cording layer, through which the laser light for recording information in the recording and reproduction area passes, and
information for calculating an optimum recording condition of at least one of the test recording area and the recording and reproduction area is recorded in a specific area of either the first information recording layer or the second information recording layer.

15. An optical information recording medium, comprising:

a first information recording layer on which information is to be recorded by laser light; and
a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer,

wherein:

the first information recording layer includes at least one of a reproduction-only area and a first recording and reproduction area,
the second information recording layer includes a second recording and reproduction area, and at least one of the reproduction-only area and the first recording and reproduction area, and the second recording and reproduction area are located such that one of the reproduction-only area and the first recording and reproduction area includes an area of the first information recording layer through which the laser light for recording information in the second recording and reproduction area passes.

16. An optical information recording medium according to claim 15, further comprising a separation layer for separating the first information recording layer and the second information recording layer from each other,

wherein:

the area of the first information recording layer, through which the laser light for recording information in the second recording and reproduction area passes, extends outward from an outer end of an area of the first information recording layer corresponding to the second recording and reproduction area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer: and NA is a numerical aperture of an objective lens for focusing the laser light to the second recording and reproduction area.

17. An optical information recording medium according to claim 16, wherein the area of the first information recording layer, through which the laser light for recording information in the second recording and reproduction area passes, extends outward from the outer end of the area of the first information recording layer corresponding to the second recording and reproduction area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

18. An optical information recording medium according to claim 15, wherein a size of the reproduction-only area of the first information recording layer is zero.

19. An optical information recording medium, comprising:

a first information recording layer on which information is to be recorded by laser light;
a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer; and
a separation layer for separating the first information recording layer and the second information recording layer from each other,

wherein:

the first information recording layer includes at a first test recording area and a non-uniform light prevention area,
the second information recording layer includes a second test recording area, and
the non-uniform light prevention area, the first test recording area and the second test recording area are located, such that a distance between the first test recording area and the second test recording area is greater than a length δ, and such that the non-uniform light prevention area includes an area of the first information recording layer through which the laser light for recording information in the second test recording area passes, the length δ being represented by:

NSDOCID: <EP_____1318509A1_I_>

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the second test recording area.

20. An optical information recording medium according to claim 19, wherein:

the first information recording layer includes at least one of a first lead-in area and a first lead-out area,
the second information recording layer includes at least one of a second lead-in area and a second lead-out area, and
the first lead-in area and the second lead-in area respectively include the first test recording area and the second test recording area, or the first lead-out area and the second lead-out area respectively include the first test recording area and the second test recording area.

21. An optical information recording medium according to claim 19, wherein the non-uniform light prevention area of the first information recording layer is a reproduction-only area.

22. An optical information recording medium according to claim 19, wherein the non-uniform light prevention area is an area formed of at least one of the group consisting of a reproduction-only area, a recording prohibited area, and a mirror area.

23. An optical information recording medium according to claim 19, wherein the area of the first information recording layer, through which the laser light for recording information in the second test recording area passes, extends outward from an outer end of an area of the first information recording layer corresponding to the second test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

24. An optical information recording medium according to claim 22, wherein the area of the first information recording layer, through which the laser light for recording information in the second test recording area passes, extends outward from an outer end of an area of the first information recording layer corresponding to the second test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

25. An optical information recording method for an optical information recording medium including a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer,
wherein:

the first information recording layer includes at least one of a reproduction-only area and a recording and reproduction area, and
the second information recording layer includes a test recording area,
the optical information recording method comprising the steps of:

recording information, in advance, in an area of the first information recording layer, through which the laser light for recording information in the test recording area is to pass; and
recording the information in the test recording area after the step of recording the information in advance.

26. An optical information recording method according to claim 25, further comprising a separation layer for separating the first information recording layer and the second information recording layer from each other,
wherein:

the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)).$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive

ANSDOCID: <EP 1318509A1 I >

index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the test recording area.

27. An optical information recording method according to claim 26, wherein the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

28. An optical information recording method according to claim 25, wherein the information which is recorded in advance is information obtained by modulating dummy information.

29. An optical information recording method according to claim 25, wherein the step of recording the information in advance includes the step of recording using a certification step.

30. An optical information recording method for an optical information recording medium including a first information recording layer on which information is to be recorded by laser light; and a second information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer,

wherein:

the first information recording layer includes at least one of a reproduction-only area and a recording and reproduction area, and
the second information recording layer includes a test recording area,
the optical information recording method comprising the steps of:

determining whether an area of the first information recording layer, through which the laser light for recording information in the test recording area passes, is an area of one of the reproduction-only area and the recording and reproduction area which is an unrecorded state or an area of the recording and reproduction area which is in a recorded state;
executing test recording in the test recording area so as to obtain a recording condition; and
calculating an optimum recording condition for the second information recording layer based on the result of the determination and the obtained recording condition.

31. An optical information recording method according to claim 30, wherein:

the optical information recording medium further includes a separation layer for separating the first information recording layer and the second information recording layer from each other, and
the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from an outer end of an area of the first information recording layer corresponding to the test recording area by a length δ, the length δ being represented by:

$$\delta = d \cdot \tan(\sin^{-1}(NA/n)),$$

where d is a distance in a thickness direction between the first information recording layer and the second information recording layer; n is a refractive index of the separation layer; and NA is a numerical aperture of an objective lens for focusing the laser light to the second recording and reproduction area.

32. An optical information recording method according to claim 31, wherein the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, extends outward from the outer end of the area of the first information recording layer corresponding to the test recording area by a length δ', the length δ' being represented by:

$$\delta' = d \cdot \tan(\sin^{-1}(NA/n)) + \delta m$$

where δm is a maximum positional offset distance between the first information recording layer and the second information recording layer.

33. An optical information recording method according to claim 30, wherein the information for calculating the optimum recording condition is recorded in a specific area of the first information recording layer and the second information recording layer.

34. An optical information recording apparatus for an optical information recording medium including a first information recording layer on which information is to be recorded by laser light; and a second

3NSDOCID: <EP_____1318509A1_I_>

information recording layer on which information is to be recorded by the laser light which has passed through the first information recording layer,

wherein the second information recording layer includes a test recording area,

the optical information recording apparatus comprising:

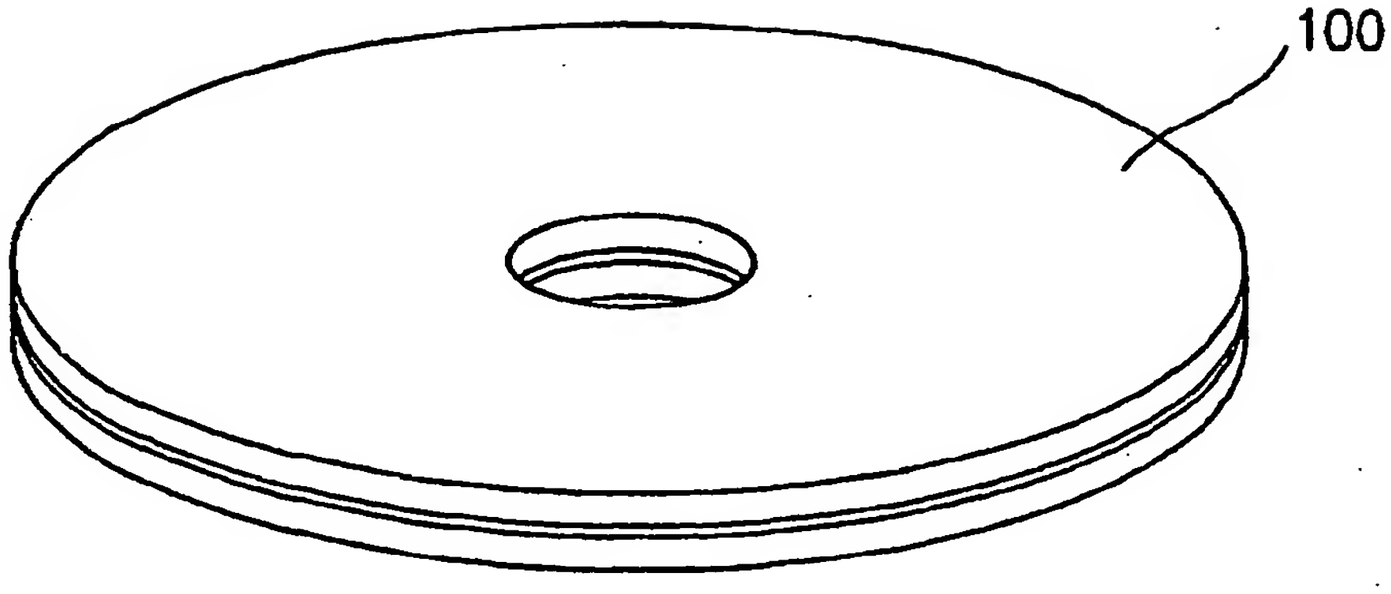
an interference area determination section for determining an area of the first information recording layer through which the laser light for recording information in the test recording area passes;

a recorded/unrecorded state determination section for determining whether the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, is in a recorded state or in an unrecorded state; and

a recording section for recording a signal in the area of the first information recording layer, through which the laser light for recording information in the test recording area passes, based on the results of the determination of the interference area determination section and the recorded/unrecorded state determination section.

3NSDOCID: <EP 1318509A1 | >

FIG. 1



3NSDOCID: <EP_____1318509A1_I_>

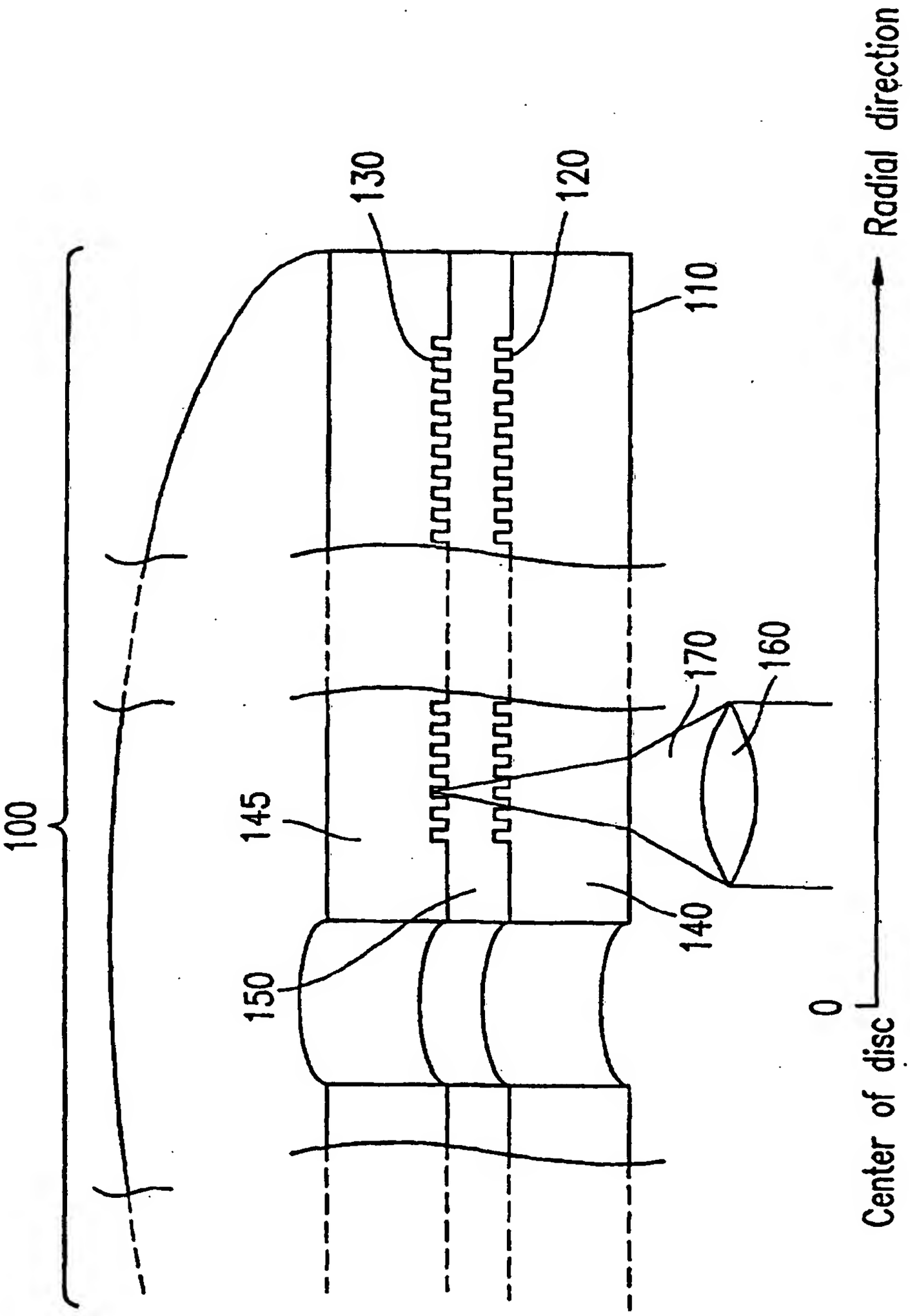


FIG.2

INSDOCID: <EP_____1318509A1_I_>

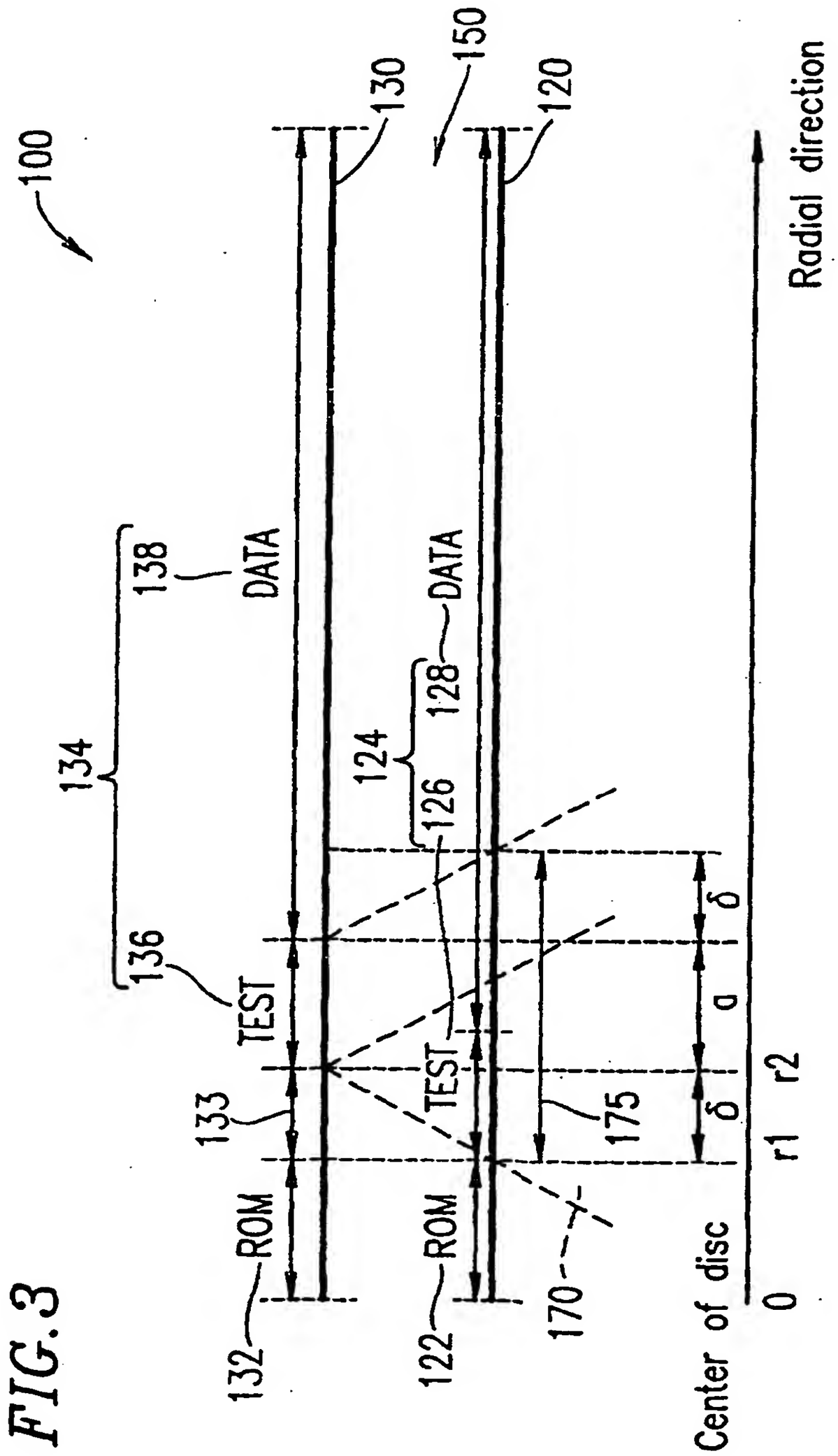


FIG.3

INSDOCID: <EP_____1318509A1_I_>

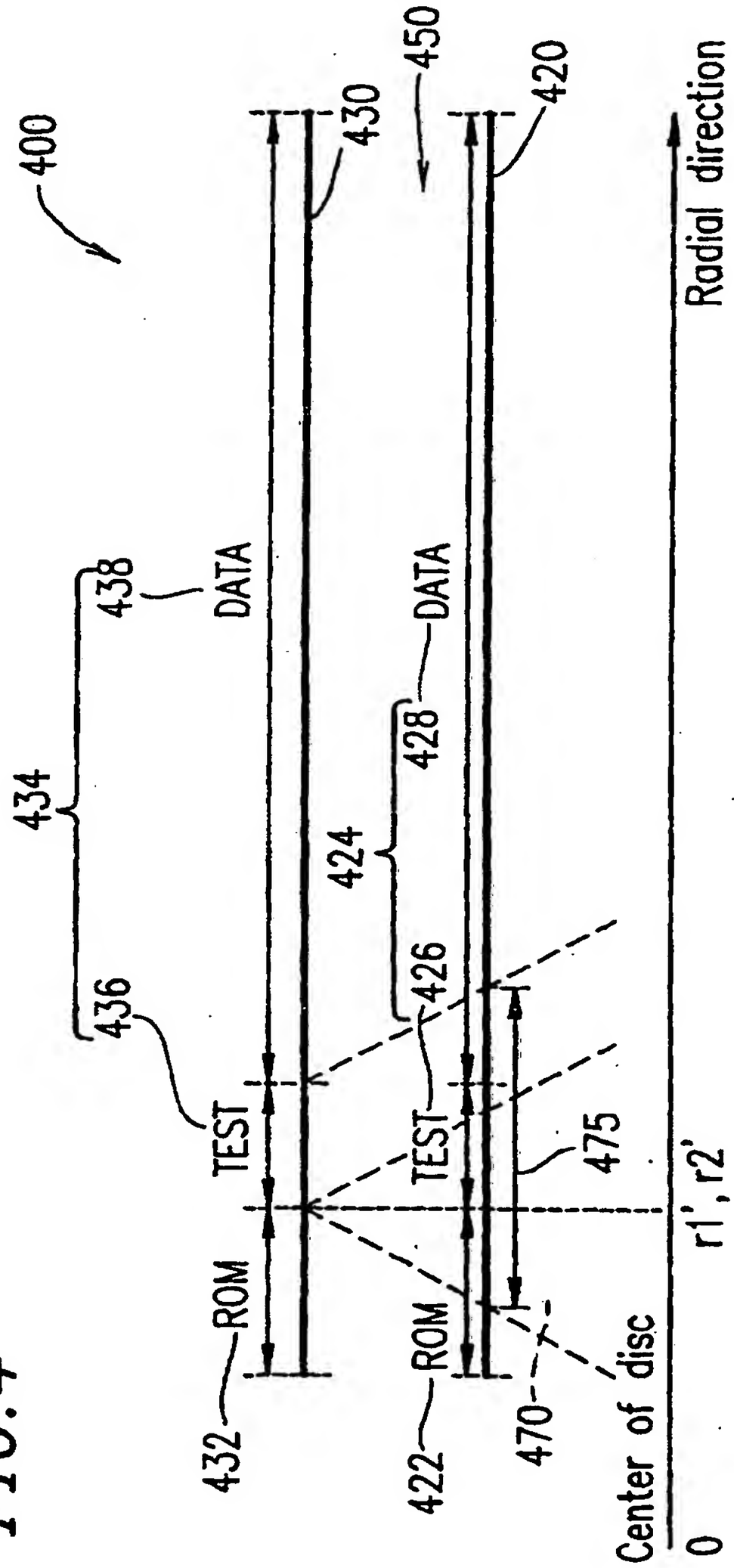
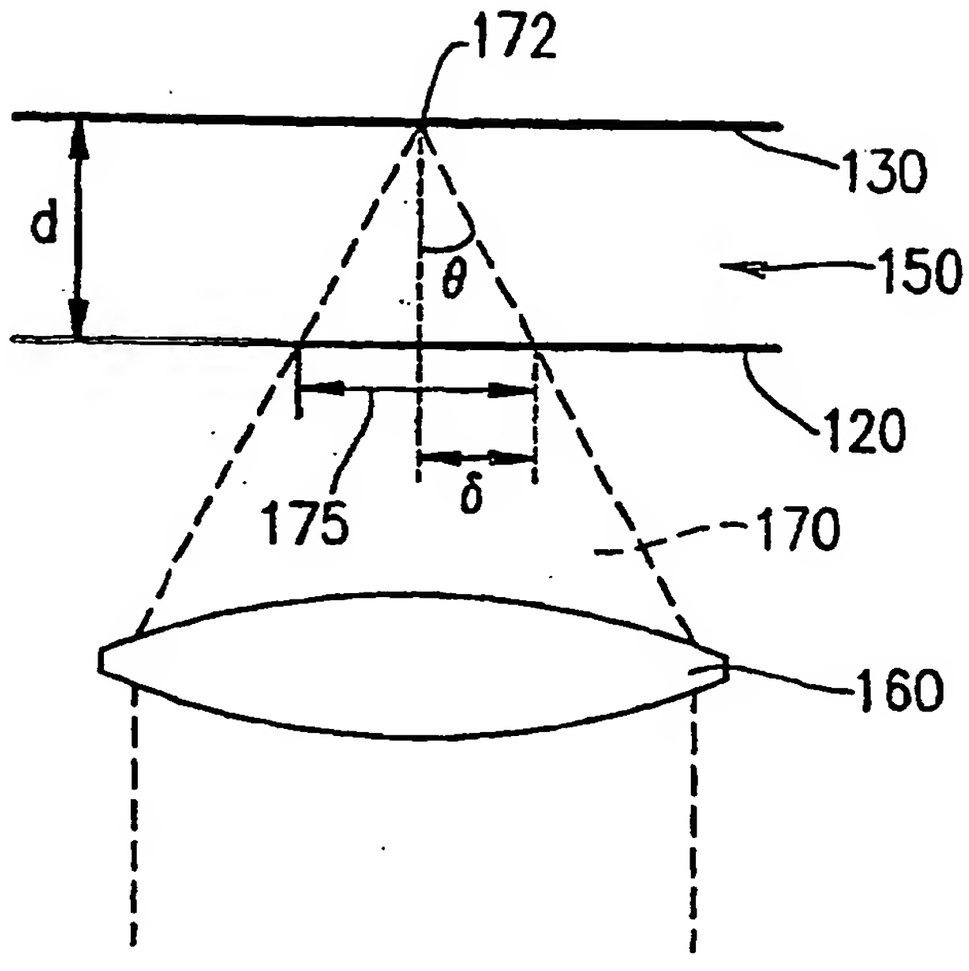


FIG. 4

3NSDOCID: <EP 1318509A1 I >

FIG.5



INSDOCID: <EP_____1318509A1_I_>

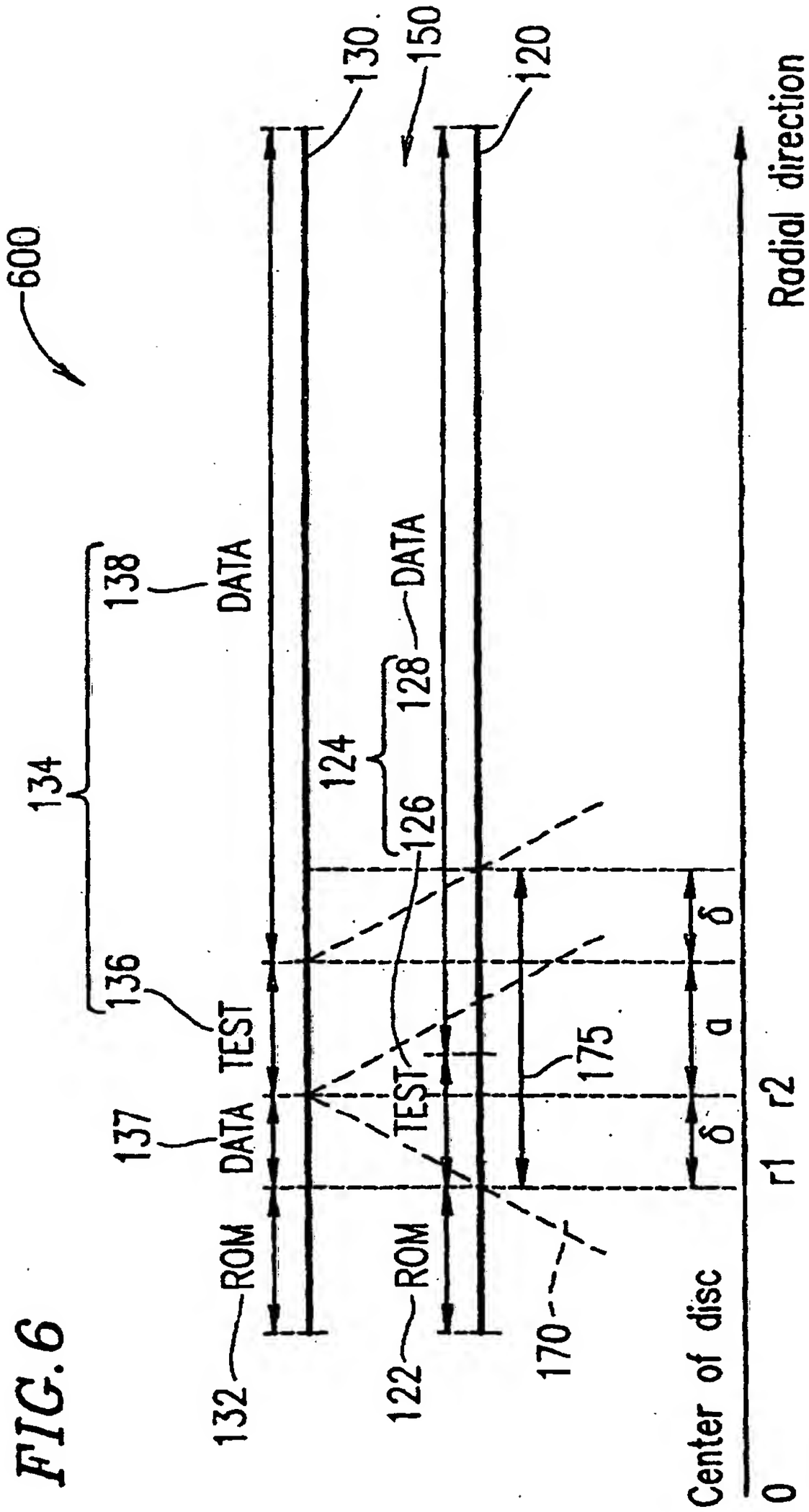


FIG. 6

EPNSDOCID: <EP 1318509A1 | >

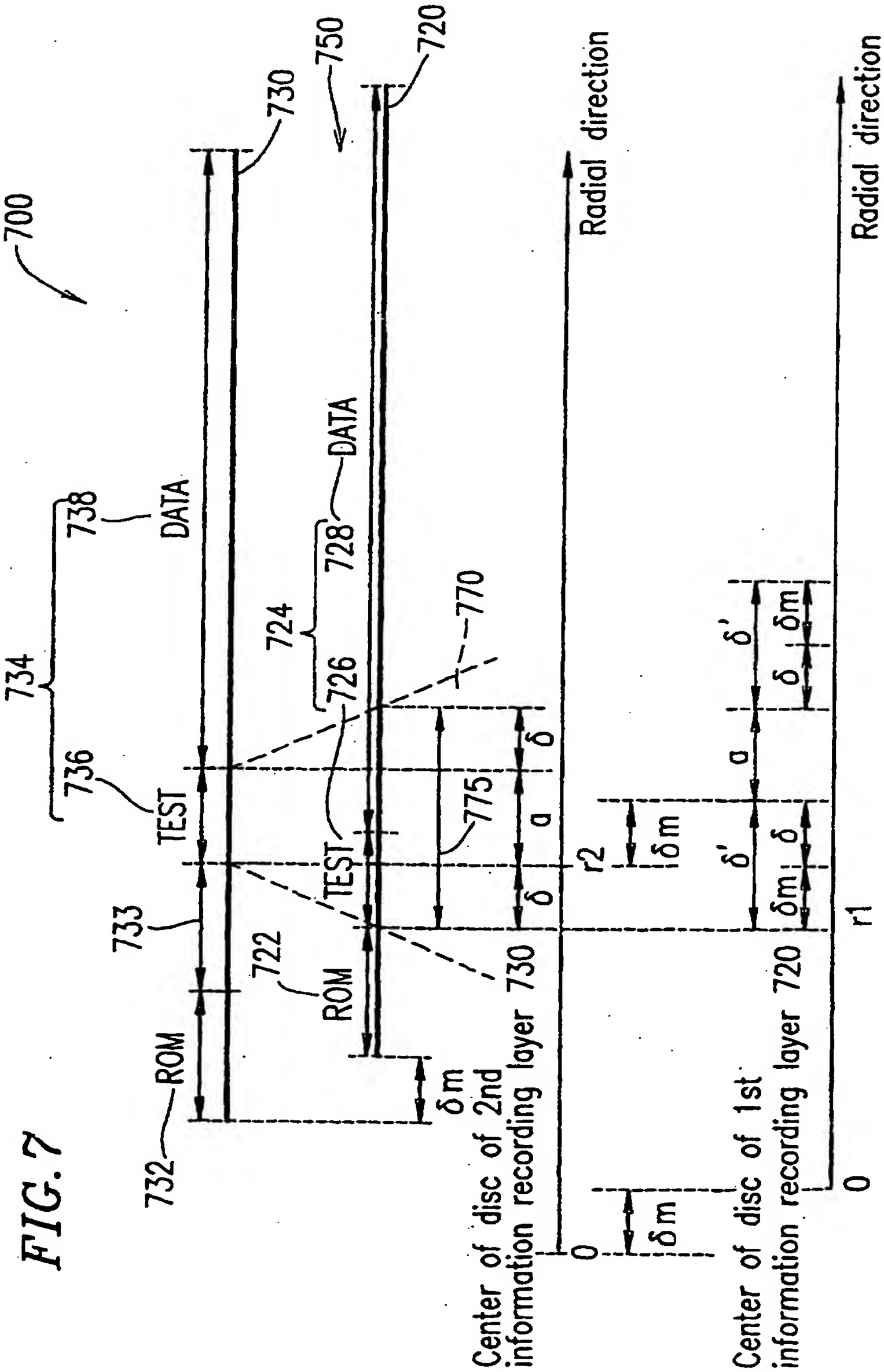


FIG. 7

INSDOCID: <EP_____1318509A1_I_>

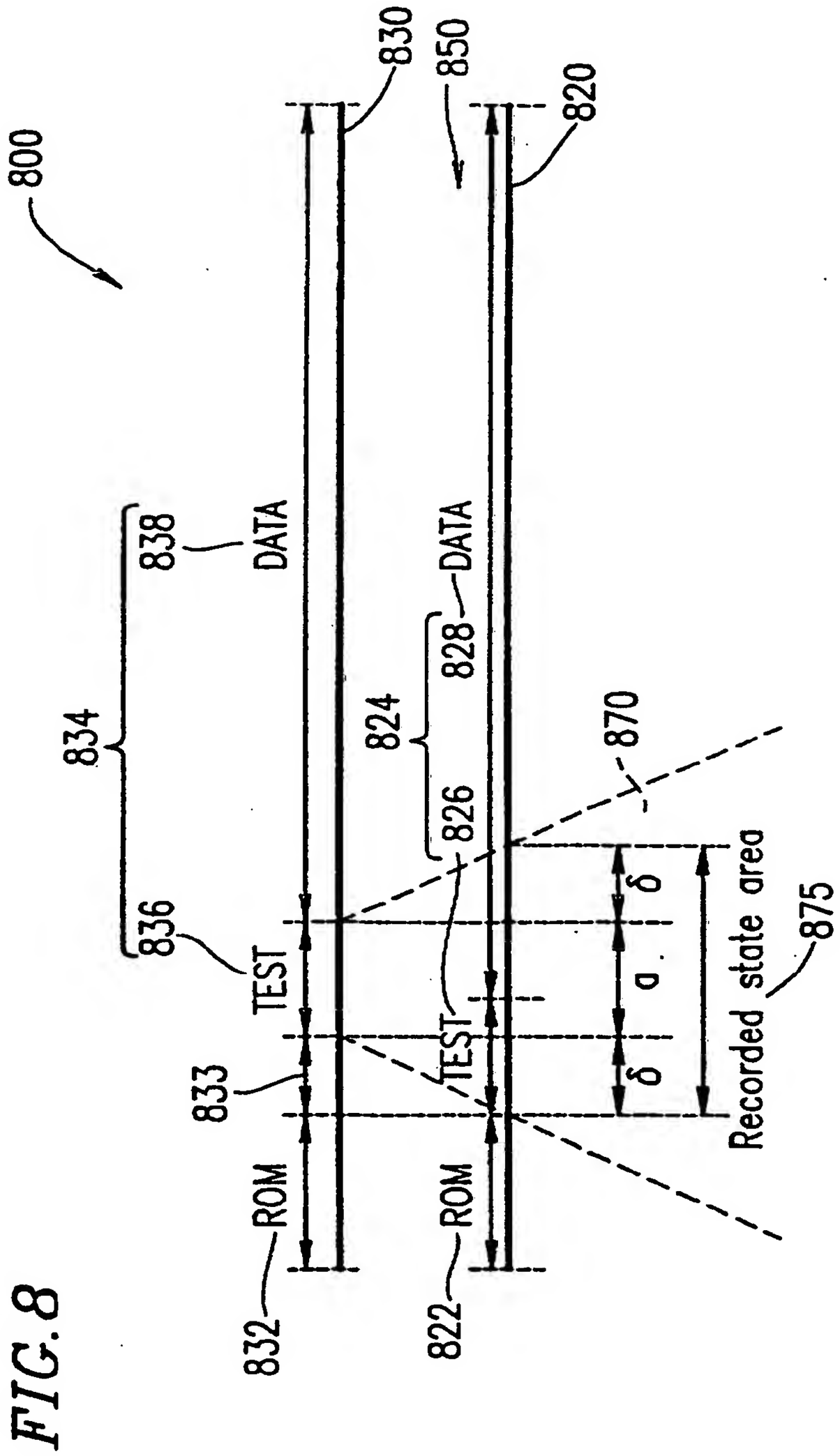


FIG.8

BNSDOCID: <EP 1318509A1 | >

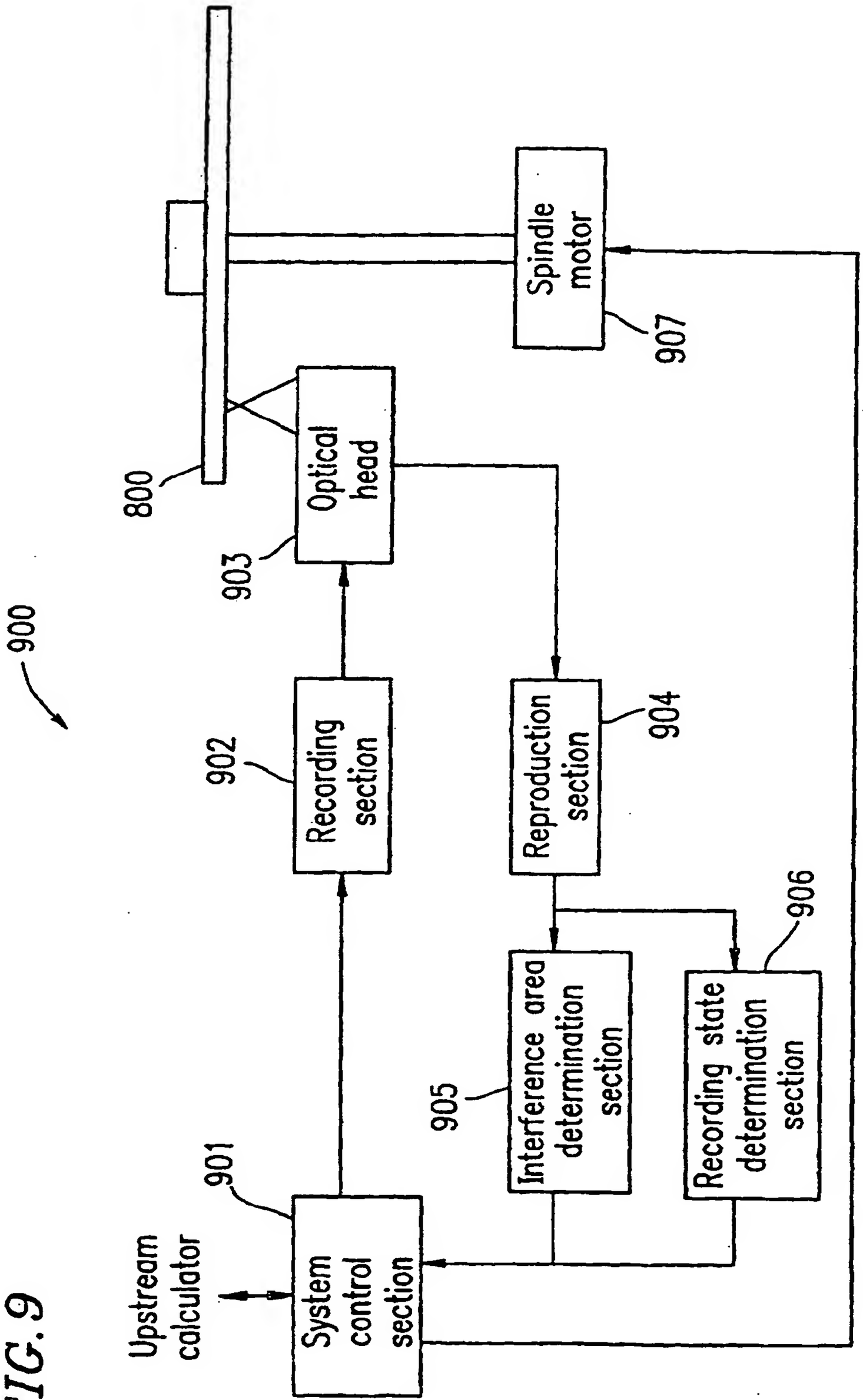


FIG. 9

BNSDOCID: <EP_____1318509A1_I_>

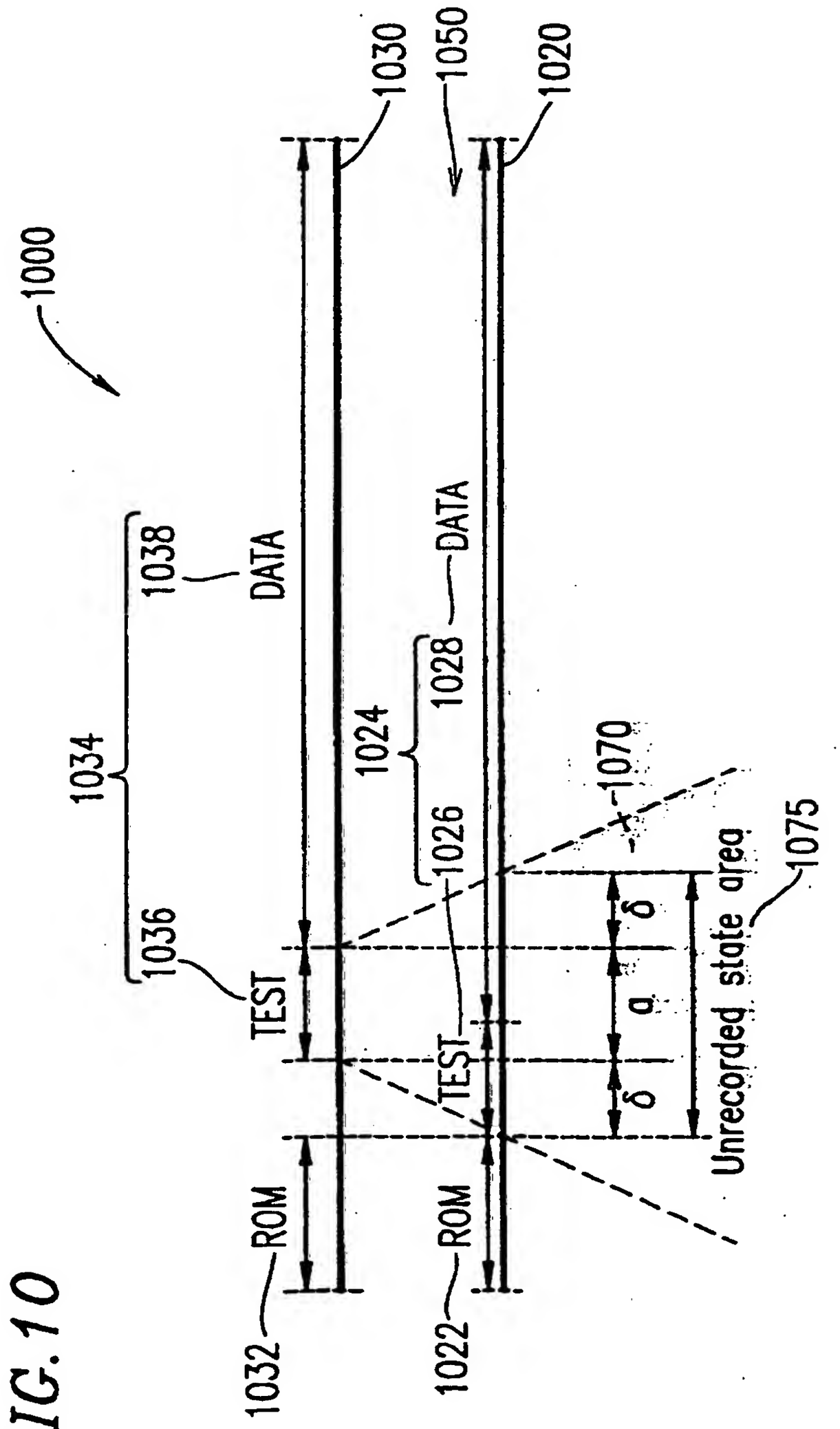


FIG. 10

BNSDOCID: <EP 1318509A1 | >

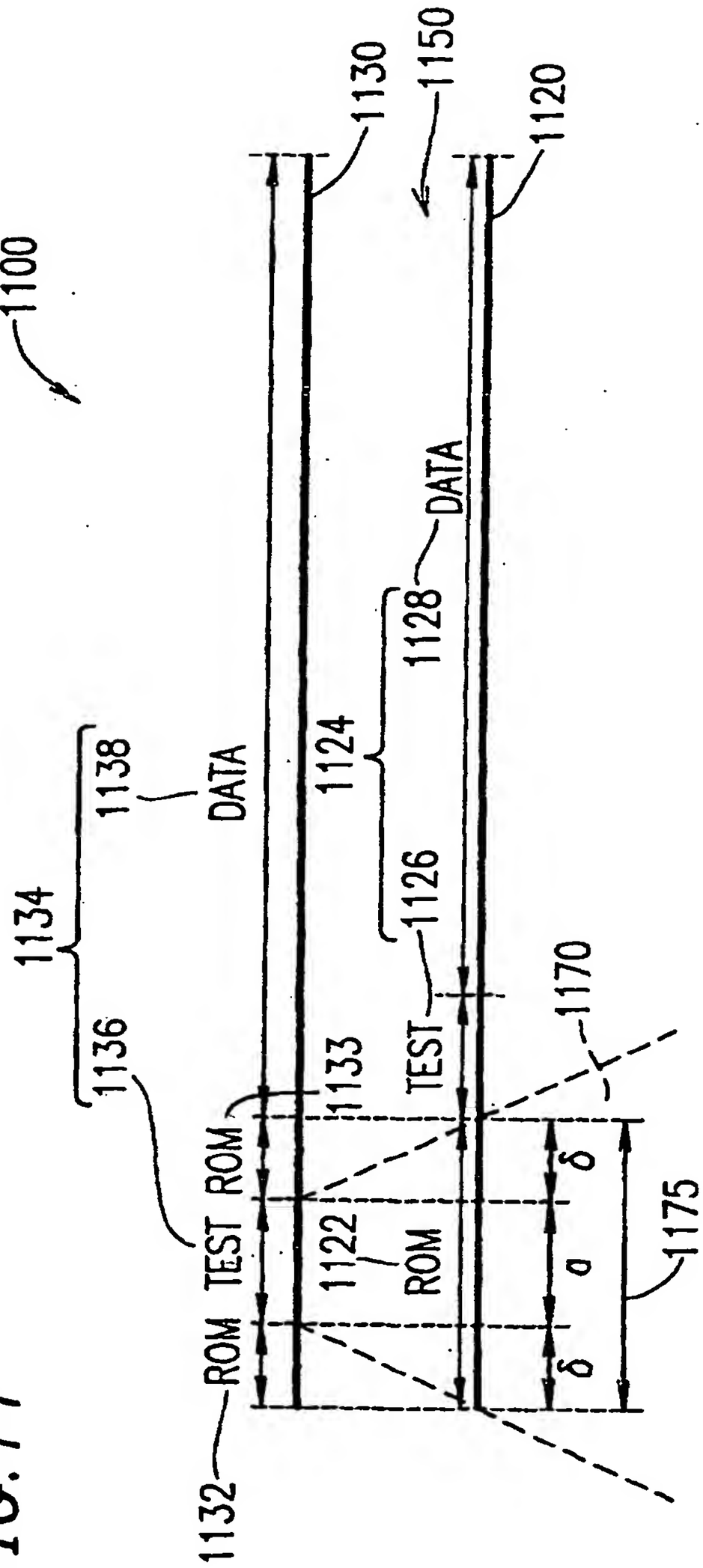


FIG. 11

INSDOCID: <EP 1318509A1 I >

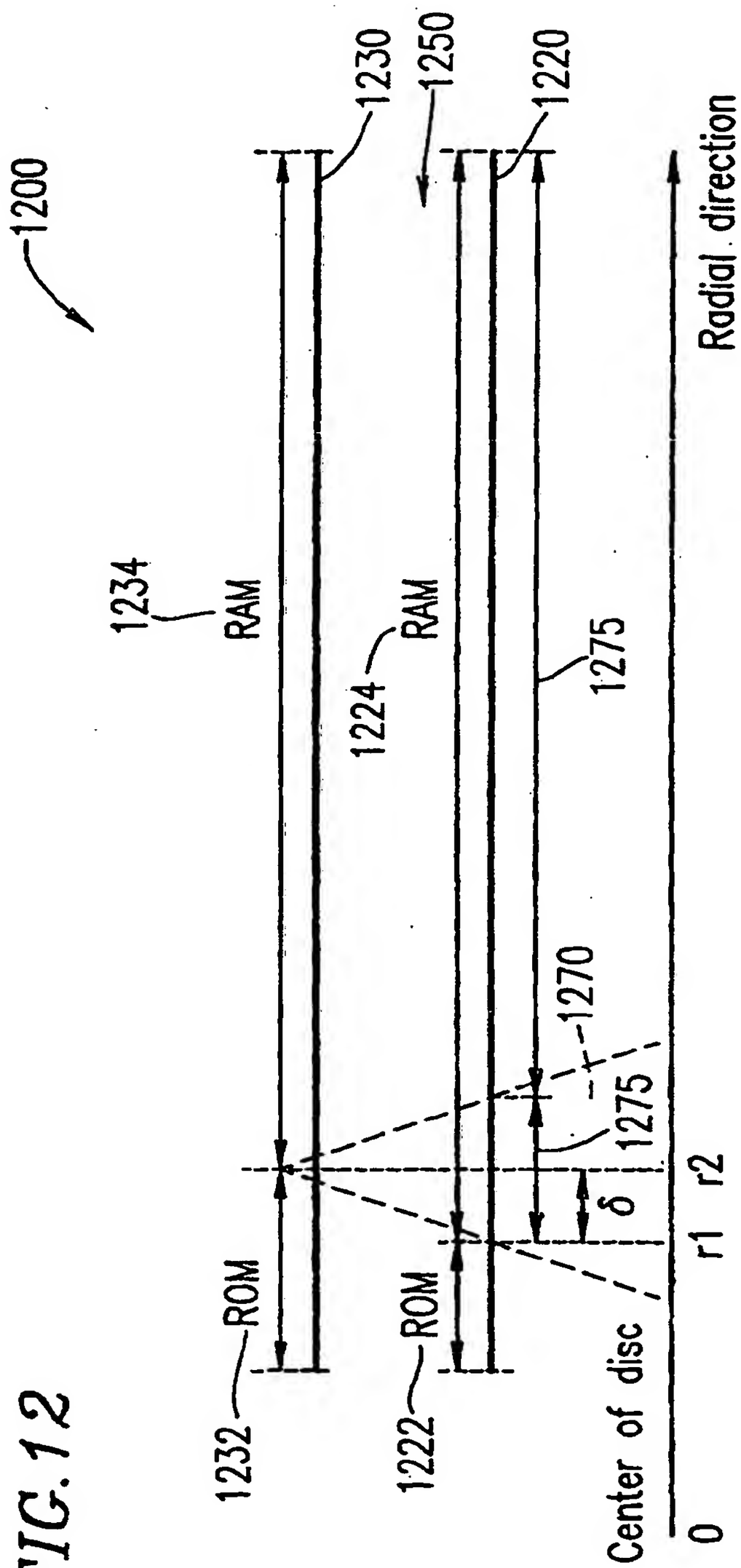


FIG. 12

3NSDOCID: <EP 1318509A1 >

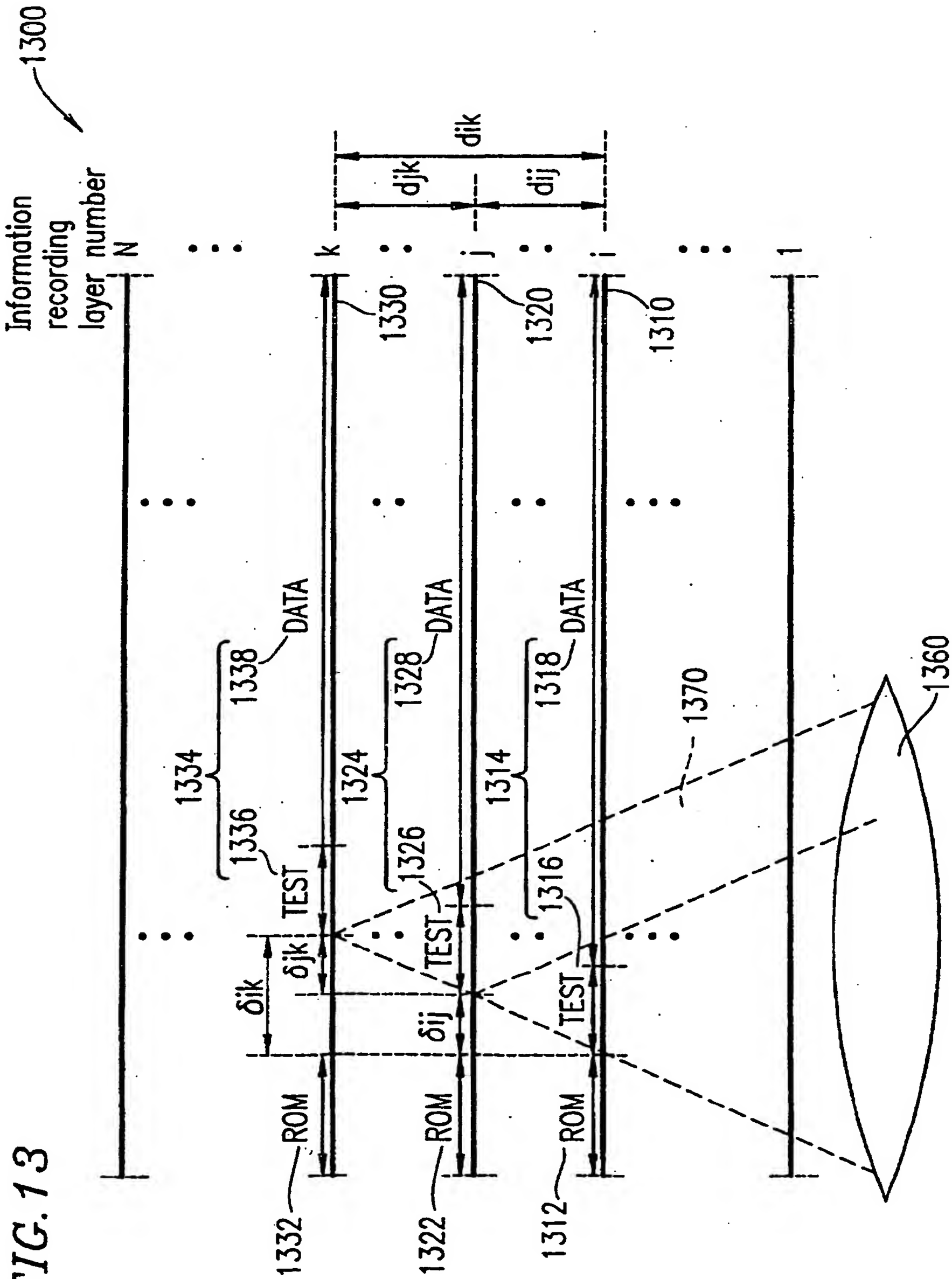


FIG. 13

3NSDOCID: <EP_____1318509A1_I_>

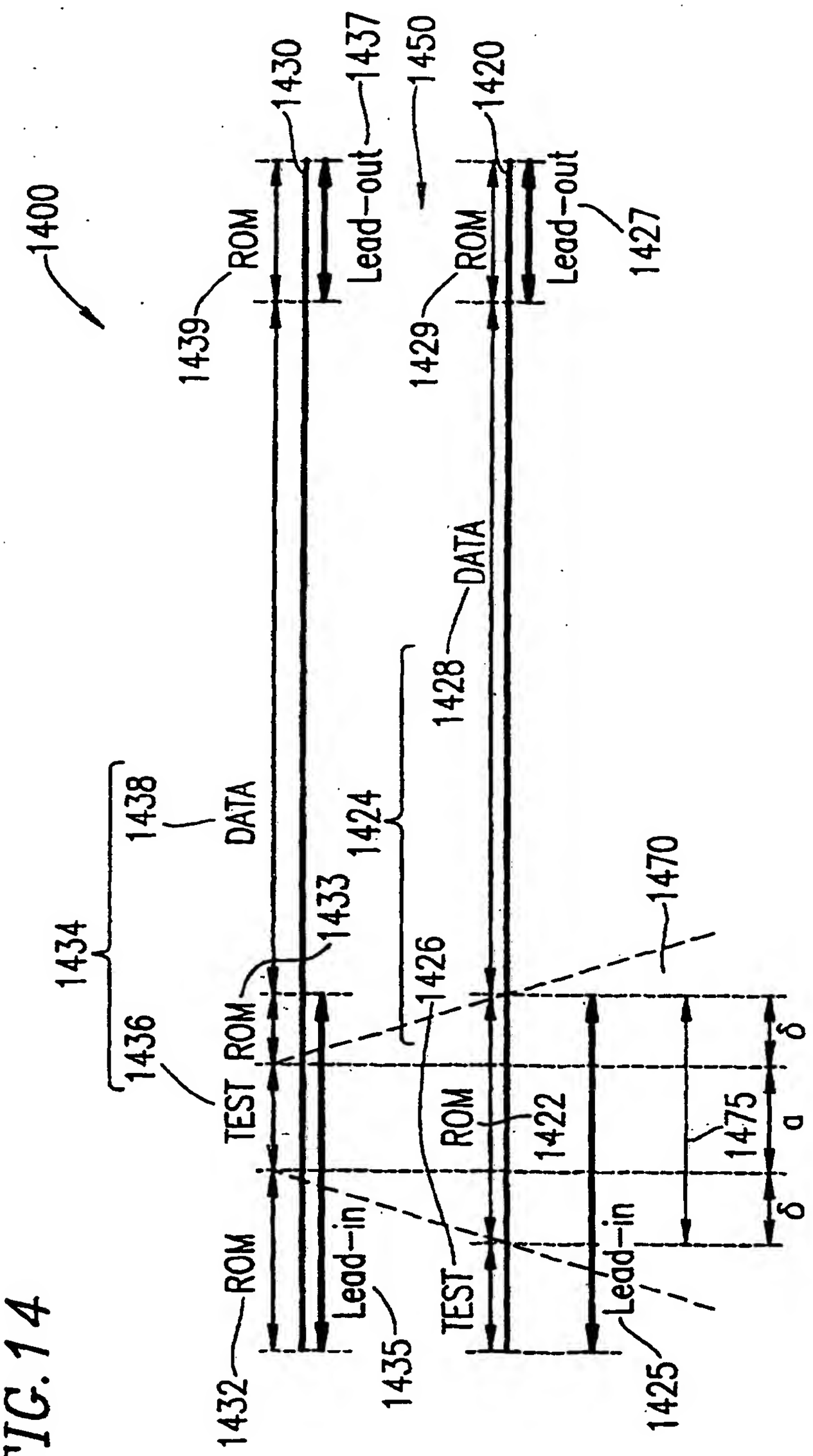


FIG. 14

3NSDOCID: <EP 1318509A1 I >

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/07927

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] G11B7/007

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] G11B7/00-013, 7/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Jitsuyo Shinan Toroku Koho 1996-2001
Kokai Jitsuyo Shinan Koho 1971-2001 Toroku Jitsuyo Shinan Koho 1994-2001

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 841658 A (Victor Company of Japan, Ltd.), 13 May, 1998 (13.05.98), Full text & JP 10-143920 A	1-34
A	JP 9-180248 A (Toshiba Corporation), 11 July, 1997 (11.07.97), Full text (Family: none)	1-34
A	JP 3-157816 A (Matsushita Electric Ind. Co., Ltd.), 05 July, 1991 (05.07.91), Full text (Family: none)	1-34

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 December, 2001 (10.12.01)	18 December, 2001 (18.12.01)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

BNSDOCID: <EP_____1318509A1_I_>